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FIRM CHARACTERISTICS AND ORGANIZATIONAL CHANGE: THE EFFECTS OF ELECTRONIC COMMERCE IN THE UNITED STATES MANUFACTURING INDUSTRY

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DISSERTATION

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ABSTRACT OF DISSERTATION

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This dissertation seeks to provide insight to how e-commerce adoption and utilization change the condition of U.S. Manufacturing establishments, by answering two interrelated questions: (1) What are the characteristics of manufacturing establishments that were early adopters of e-commerce activities?; (2) Once e-commerce is adopted, how has adoption affected employment within manufacturing establishments? The U.S. manufacturing industry was selected for analysis as manufacturing has been and continues to be an important sector for employment and the overall U.S. economy and has been the primary sector responsible for the majority of Business-to-Business e-commerce activity.

Using two econometric models, seemingly unrelated regression (SUR) and three stage-least squares (3SLS), this dissertation confirms previous research pertaining to the characteristics of firms that were early adopters of e-commerce. However, this dissertation also provides insights for how manufacturing firms change after the implementation of e-commerce. Specifically, findings suggest that e-commerce adoption has a negative effect on manufacturing jobs between 1999 and 2005. Simultaneously, the loss in jobs does not translate into an increase in wages for those still employed. The findings of this dissertation also do not provide a positive outlook for a “spatially equitable landscape” to develop via the dissemination of e-commerce in the U.S. manufacturing industry. Rather, the results suggest that the application of e-commerce will continue to reinforce the geographical advantages of firms in urban areas verses those located in more rural areas.

KEYWORDS: e-commerce, manufacturing, labor, knowledge spillovers, innovation diffusion

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I dedicate this work to:

Alexander Wallace Barnes for inspiring me to finish this journey

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1. Why Manufacturing Still Matters for Employment in the United States

Introduction

Manufacturing has been and continues to be an important source of employment for the United States (U.S.) economy. Manufacturing jobs traditionally have paid high wages, been an avenue for relatively lucrative blue-collar employment, and provided economic stability for a large number of working-class Americans. Manufacturing also serves an important role in the U.S. economy by directly contributing to GDP through the export of manufactured goods. As of 2012, U.S. manufacturing ranked tenth in terms of GDP among the world's economies (Timmons et al. 2012).

The direct monetary effects of the manufacturing sector on the U.S. economy are even higher when indirect multiplier effects are taken into account. For example, the manufacturing industry indirectly plays an important role in the economy through the creation of horizontal linkages to the service sector, such as firms in the financial and business services sectors that support manufacturing operations (Cohen and Zysman 1987). However, over the last half-century, and especially the last 30 years, jobs in the U.S. manufacturing industry have declined significantly, eroding the financial security of middle- and working-class Americans. The manufacturing sector's share of nonfarm employment in the U.S. has fallen from 32 percent in 1950 to just 10 percent in 2009, while the $2.1 trillion in GDP generated by manufacturing in 2013 contributed just 12.5 percent of the national total, a nearly 50 percent decrease in share since 1979 (Scott 2015).

Manufacturing employment reached its height in the U.S. in 1979 (BLS 2013). Although three key recessions, (1990-1991, 2001, and 2007-2009) contributed significantly to the declines in manufacturing employment, declines have also been at least partly attributed to technological and organizational changes, not to mention a number of broader structural and policy shifts occurring simultaneously since the 1970s. For example, key among these technological innovations has been the widespread adoption of just-in-time production systems, which have enabled corporations to shift production to cheaper export platforms while also weakening the relative position of the often-unionized manufacturing workforce (Bluestone and Harrison 1982; Harvey 1989; Schoenberger 1994). Through the utilization of time-space compressing technologies – from advances in information and communication technologies allowing for an acceleration of communications to new, more efficient ways of transporting goods across great distances – manufacturing companies have found a variety of ways to achieve their ends without being so heavily reliant on the traditional manufacturing workforce.

In more recent years, the focus has turned to the role of the internet in business-to-business (B2B) exchanges. Streamlining the movement of manufactured goods from one company to another, not to mention adding efficiencies in the marketing and purchasing of those goods may result in dramatic changes in the U.S. economy. These changes could result in continuing decreases in manufacturing employment. Yet, little research has focused on the early adoption and integration of electronic commerce (e-commerce) to determine systematically how the U.S. manufacturing sector changed. This dissertation turns to that undertaking and in particular addresses the following two questions:

1) What were the characteristics of manufacturing establishments that implemented e-commerce when e-commerce began emerging as a business strategy?
2) Once manufacturing establishments adopted e-commerce strategies, what was the effect on establishment employment and wages?

The remaining portion of this chapter further expands on the significance of the U.S. manufacturing industry in the national economy and at the local level. Then I turn to a general discussion on the role of the internet and e-commerce, and how these two technological advances have the ability to fundamentally change the manufacturing industry. I conclude the chapter by providing an overview of the additional chapters included in this dissertation.

The Continued Significance of Manufacturing

Manufacturing in the U.S. reached its zenith in 1979, at least in terms of total employment. Coinciding roughly with the shift to a post-Fordist mode of production in the developed world in the early 1970s (Amin 1994), this loss of manufacturing jobs has been significantly attributed to the development of new technologies of automation that decreased the need for a large workforce, as well as, to shifting regulatory regimes. Regulation changes, which allowed companies to more easily move their operations overseas, and a range of time-space compressing technologies in communication and transportation which allowed for sustained, close interaction even at a distance, also contributed to the reduction in manufacturing jobs. As part and parcel of this shift, the U.S. economy has undergone widespread informationalization and financialization, captured most commonly in terms such as ‘the knowledge economy’ or ‘information economy’. And while these emerging sectors contribute greatly to growth in the U.S. economy and its continued role in shaping social, economic and political relations across the globe, manufacturing continues to hold a significant place within the national economy. Despite the fact that the United States saw substantial declines in manufacturing employment throughout the 2000s – even predating the 2007-08 financial crisis – to the tune of 5.7 million (or 33 percent) jobs, nearly 15 percent of total GDP growth in the US during this decade came from the manufacturing sector (Atkinson 2013).

Part of the reason the manufacturing industry has traditionally played an important part in the national economy is because of the historically high paying positions for workers that may not have completed education requirements beyond the high school level. Manufacturing employees typically receive higher compensation as compared to individuals employed in other sectors—as high as 19 percent (Timmons et al. 2012). As income inequality in the United States reaches record levels, with the labor market increasingly bifurcated between high-wage workers in emblematic industries in Silicon Valley and Wall Street and low-wage, largely precarious service workers who support them, the relatively stable, high-wage jobs characteristic of manufacturing continue to disappear. Although the growth of the internet has spawned a range of new opportunities for economic growth and development in certain places like Silicon Valley, a smaller and smaller proportion of American workers are able to achieve the kind of comfortable, middle-class lifestyles common in the mid-twentieth century that were created through the continued growth of the manufacturing sector (Fukuyama 2012).

While the loss of manufacturing jobs in particular has had a devastating effect on many localities within the United States, these losses have been compounded by the fact that the manufacturing sector maintains myriad forward and backward linkages with the service sector. That is, when the relatively large and stable manufacturing workforce starts to disappear, so does the support for a range of both producer and consumer service activities. Using data from the Bureau of Economic Analysis (BEA), Timmons et al. (2012) demonstrate that for every dollar in final sales of manufacturing products in the US, those sales support $1.34 in output from other sectors—the highest multiplier of any other sector. As manufacturing jobs are eliminated or off-shored in significant number, so too are the service jobs, especially those that are closely linked with the manufacturing activities and require some level of spatial co-presence. As of 2010, approximately 7 million jobs in sectors outside of manufacturing were estimated to be directly dependent on the manufacturing industry (AMNPO, 2015)

Rather than the oft-cited argument that the loss of manufacturing jobs allows for now-unemployed workers to re-skill and fill new kinds of high-wage tertiary or quaternary sector jobs, Cohen and Zysman (1987) argue that "If the U.S. loses control and mastery of manufacturing production, it is not simply that we will not be able to replace the jobs lost in industry by service jobs; nor simply that those service jobs will pay less" (20), but instead, the situation is such that "lose manufacturing and you will lose—not develop—high wage service jobs" (24). That is, the service and, increasingly, information processing sectors are not substitutes or logical out-growths of, but compliments for manufacturing, with "[c]omplementarity or interdependence…more accurate description[s] of the relationship than substitution or succession" (37). Although the work of Cohen and Zysman (1987) is relatively dated at this point and somewhat of a relatively simplistic treatment of manufacturing in the U.S. economy today, there is still validity in their arguments concerning the role of manufacturing and the “support” services sectors that are vertically integrated with those firms.

And while the ‘death of distance’ thesis may argue that many of these tertiary and quaternary jobs could continue to be done from their current or previous locations in the U.S., the reality is that the processes of agglomeration and clustering – whether in manufacturing, telecommunications or other industrial sectors – are much more persistent than was once expected (Brown et al. 2009).

The Geography of Manufacturing Decline

As manufacturing continues to be an important part of the U.S. economy, geography has played a key role in the historical development and more recent decline of U.S manufacturing. Although manufacturing has declined in general across the United States, the negative impacts of this decline have been concentrated in particular places, while some other localities – both near and far – have been left to benefit. At its peak, American manufacturing was particularly concentrated in the Great Lakes states, or what is now more commonly referred to as ‘the Rust Belt’, a moniker telling of the connection between industry and region. According to Hill and Negrey (1987);

> “In 1960, Great Lakes manufacturing accounted for 48 percent of U.S. industrial work, and the Great Lakes states generated 42 percent of all jobs in the nation. By 1985, the Great Lakes share of manufacturing had declined 12 percentage points, and the region accounted for less than one-third of the nation’s nonagricultural employment” (591-592).

Indeed, Hill and Negrey note that even as other parts of the country have experienced cyclical increases in manufacturing employment – or been able to replace previously lost manufacturing jobs with new industries – these states have been unique in that their economic decline has only deepened over time.

While the Rust Belt has come to symbolize the decline of manufacturing in the U.S., Detroit in particular has become the poster-child for the ill-effects of an *over*-reliance on manufacturing employment. At its peak, Detroit's population was the fifth-largest of any city in the United States, with over 1.8 million people as of the 1950 census. However, the city declined slowly over the following decades, with just 1.2 million residents as of 1980 and just 713,777 in 2010. The US Census Bureau estimates just 688,701 residents of Detroit as of 2013. Similarly, Detroit generally ranks as having the highest unemployment rate (23.1 percent) and the highest percentage of residents living in poverty (36.4 percent) of any large U.S. city (U.S. Census Bureau 2013). While the city's decline began well before the precipitous decline of the crisis-ridden late-1970s, nearly half of the city's 98,700 lost manufacturing jobs (or about 48 percent of the total manufacturing jobs in the city) between 1958 and 1982 occurred after 1977 (Darden et al. 1987, cited in Ryan and Campo 2013).

At the broader scale of the city-region, the location of manufacturing facilities actually played a key role in facilitating this decline throughout the post-WWII years up until the structural crises of the late 1970s. Construction of new manufacturing plants in the region occurred largely outside of Detroit in new suburbs, both catering to and further facilitating the movement of (largely) white Detroiters into the suburbs for jobs and away from social unrest in the city. Detroit's share of regional manufacturing employment had fallen all the way to 25 percent by 1982, a decline of 15 percent since 1963 and 35 percent since 1948 (Darden et al 1987), signifying not an overall loss of jobs within the region, but a spatial restructuring of those jobs towards different areas of the city-region. It is also important to note that some, such as historian Thomas Sugrue (1996) argue that while Detroit's decline was due largely to these processes of deindustrialization, it is more accurate to place their genesis in the immediate post-WWII period as technological change (in this case the mechanization of factories) had already begun to displace larger and larger numbers of workers.

As the Detroit region, and the Rust Belt more generally, has felt the losses of manufacturing jobs and capital investments, other localities have reaped the benefits. The economic organization of Fordism gave way to the post-Fordist restructuring of manufacturing in the U.S., so too has the geography of the Fordist economy given way to the creation of 'new industrial spaces' (Scott 1988). Whether in peripheral enclaves within longstanding urban centers (e.g., the film industry in Los Angeles or the high-tech sector along suburban Boston's Route 128) or relatively isolated new developments in the so-called Sun Belt, the spatial extent of manufacturing in the U.S. continues to be shaped by a variety of geographical factors. As Peet (1983) highlights, arguably one of the key factors in this shift of manufacturing employment away from traditional Rust Belt cities is the role of labor unions, as such declines correlate closely with various metrics of workforce unionization and work-stoppages, among other things.

Ultimately, even these new industrial spaces (albeit at present they are perhaps better referred to as "middle-aged" spaces) have been negatively impacted by the shift of manufacturing jobs offshore. While the number of manufacturing jobs fell across the country by an average of 17 percent in the five years following the 2007-2008 financial crisis, Rust Belt states in the Midwest and Sun Belt states in the Southeast were more likely to experience the sharpest declines (Timmons et al. 2012). In spite of such across-the-board declines in manufacturing employment across the United States, manufacturing continues to play an important – albeit diminished – role in the American economy. Through the adoption of new technologies of both production and networking between firms, some manufacturing firms have been able to maintain key advantages in the marketplace and continue to provide middle-class jobs, as the competitive advantages offered by these new technologies continue to make the U.S. a global competitor in high-value manufacturing (Mendelbaum 2009).

Manufacturing, the Internet and E-Commerce

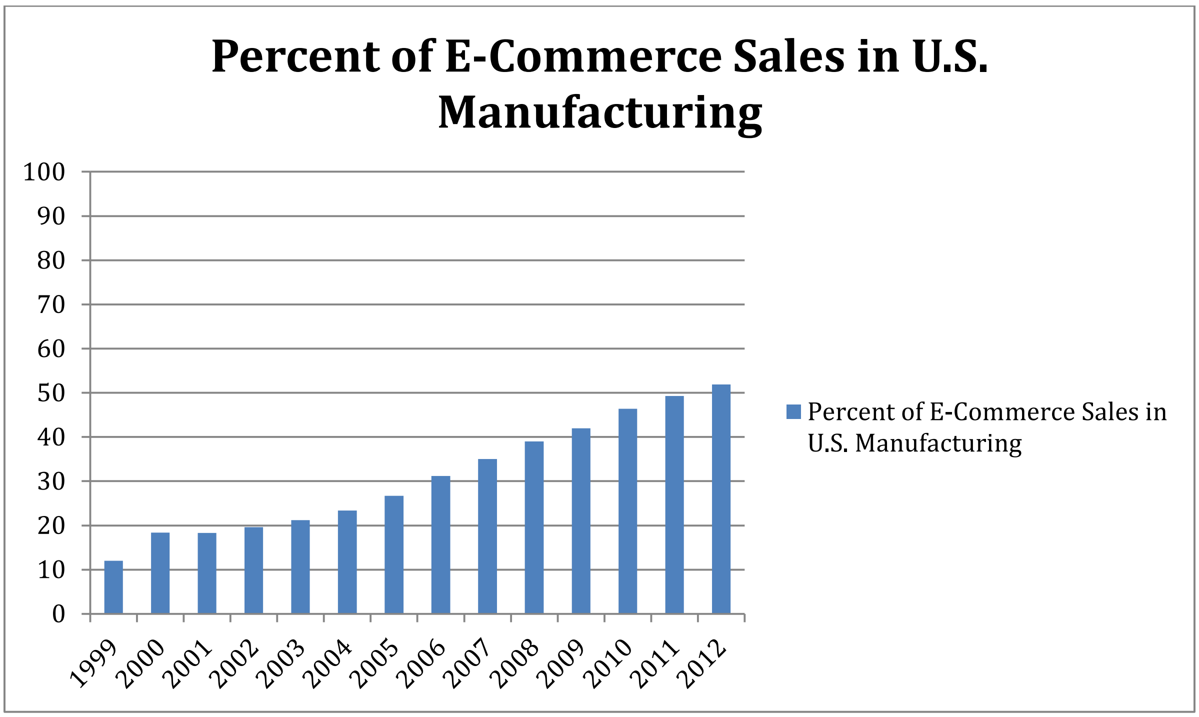
Over the last fifteen to twenty years, the increasing availability of the internet, and especially its increasing integration to the everyday functions, activities and practices of the global economy, has led a range of scholars to investigate how these new information and communication technologies are helping to change the global economy (Malecki 2004; Van Geenhuizen 2004; Kellerman 2002; Drennan 2002; Kotkin 2001; Leamer & Storper 2001; Zook 2000). Although the neologism "e-commerce" is relatively recent, the concept of e-commerce, and the role of information and communication technologies in industrial production systems, has a much longer history. Computer-based electronic information systems were first implemented in the 1960s through the use of electronic data interchange (EDI) systems. The impact of these systems, however, was limited for a number of reasons, including: (1) the high level of expertise needed to operate them, (2) the high cost of these systems relative to the limited volume of information, and (3) the lack of standardization between each EDI system (Shen et al. 2004). But by the late 1990s, the convergence of multiple technological innovations allowed for new methods for exchanging information. Essentially, e-commerce developed out of the combination of EDI, the Internet, e-mail, and the world wide web (www) (Leinbach 2001).

The growth and increasing importance of e-commerce in the late 1990s and early 2000s fostered a range of definitions and theories of e-commerce, attempting to pin down its essential nature and what it would mean for individual firms and for the broader economy (Zwass 1996, 2003; Swatman 1996; Wigand 1997; Clarke 1999; Poon 1998). For example, Chan and Swatman define e-commerce as “the undertaking of normal, commercial, government, or personal activities by means of computers and telecommunications networks; and includes a wide variety of activities involving the exchange of information, data, or value-based exchanges between two or more parties” (Chan and Swatman 1999). Put more simply, Kraemer et al. (2005) define e-commerce as “the use of the Internet to buy, sell, or support products and services.” Ultimately, such broad, conceptual definitions of e-commerce have made it difficult for scholars to coalesce around a specific research agenda pertaining to e-commerce (Elia et al. 2007). From attempting to understand the impacts of firms leveraging e-commerce to how it impacts the spatial division of labor, there has been no shortage of attention to and celebration of these new technologies (Fillis et al. 2004; Porter 2001; Lee 2001; Weill and Vitale 2001; Shaw et al. 2000; Garicano and Kaplan 2001). The complexity of e-commerce research is partly due to the fact that e-commerce does not constitute a single technical innovation, but rather is comprised of overlapping clusters of both technological and organizational innovations that have a variety of impacts on firms and other organizations in different areas and at different levels of their business processes and practices.

The adoption and integration of e-commerce into U.S. manufacturing should enable firms to further optimize their production systems and improve their efficiency. Porter (1990) contends that the application of technology has both allowed and sometimes coerced firms to become more efficient to increase their competitiveness under the capitalist economic system. As firms continually look for new ways to achieve competitive success within their respective industries, advances in information technology provide new opportunities for more efficient business organization and structure. Porter contends firms must enjoy a competitive advantage in the form of either lower costs or differentiated products that command premium prices to attain competitive success. To sustain an advantage, firms must achieve more sophisticated competitive advantages over time—either by providing higher-quality products and services or producing them more efficiently; instead of maximizing production within fixed constraints, firms can gain competitive advantage from changing their constraints (Porter 1990). Again, e-commerce is a technology that can permit that changing of constraints when implemented in an efficient manner. However, gaining a long-term competitive advantage merely by integrating e-commerce is unlikely as eventually other firms will adopt it and decide on its optimal use.

Understanding how e-commerce is adopted, integrated, and utilized by firms in the U.S. manufacturing industry is important because of their role in the overall U.S. economy. And based on the e-commerce data collected by the U.S. Census Bureau, sales via e-commerce continue to increase. In 2012, manufacturing e-commerce sales were $3.0 trillion in 2012, up 10.5 percent from 2011. As a percentage of total sales in the manufacturing industry, 2012 marked the first time that sales via e-commerce surpassed the 50 percent mark. Figure 1.1 demonstrates the increasing nature of e-commerce sales in the U.S. manufacturing industry since the Census Bureau began collecting the data in 1999.

Figure 1.1: Percent of E-Commerce Sales in U.S. Manufacturing from 1999 to 2012



Source: compiled from U.S. Census Bureau E-Stats data: http://www.census.gov/econ/estats/

Historically, the U.S. manufacturing industry has been the leader out of all industry sectors in terms e-commerce sales. However, e-commerce has not spread evenly across the manufacturing industry. In 1999, approximately 63 percent of all e-commerce shipments were concentrated in the following five industry groups: (1) transportation equipment (NAICS 336), (2) food products (NAICS 311), (3) chemicals (NAICS 325), (4) machinery (NAICS 333), and (5) computer and electronic products (NAICS 334) (Census 2002). In 2000, e-commerce sales were again concentrated in the five industry groups identified above, although sales via e-commerce were becoming more pervasive across the entire manufacturing industry, accounting for 10 percent of sales in 16 of the 21 manufacturing subsectors. In 2008, e-commerce sales account for over 20 percent of sales in 21 of the 21 manufacturing subsectors (Census 2011). By 2012, 11 of the 21 manufacturing subsectors had e-commerce sales that accounted for more than 50 percent of their total manufacturing shipments (Census 2014).

The statistics above demonstrate that e-commerce sales have grown substantially in just 13 years. Given these historical trends, it seems reasonable to assume that they will continue, as more and more firms conduct their sales via e-commerce. Thus, given the role of manufacturing in the overall U.S. economy and the importance of e-commerce as the sales vehicle for the manufacturing industry, it is integral to understand the impacts of these changes.

Dissertation Findings and Overview

Again, the overall aim of this dissertation is to 1) determine which characteristics were determinants for firms that were early adopters of e-commerce, and 2) analyze the effects of e-commerce adoption on establishment labor, specifically how e-commerce technologies affects the number of employees and wages. My results regarding the characteristics for firms that were early adopters of e-commerce determine that larger, export oriented firms that are co-located geographically with other manufacturing firms using e-commerce and in industries using e-commerce heavily themselves were more likely to report high e-commerce adoption and intensity. As for how e-commerce affects establishment labor and wages after it is adopted and implemented within a firm, my results demonstrate that increasing e-commerce usage appears to lead to lower employment levels. At the same time, despite the shrinkage in employment, there is no reliable expectation that those remaining at the establishment will receive an increase in pay.

The results summarized in the previous paragraph are thoroughly examined throughout the remainder of this dissertation. It is organized in the following manner: chapter 2 reviews the scholarly literature exploring the relationships between technological change, its role in the capitalist economy and e-commerce. Chapter 2 also focuses on e-commerce adoption and the business firm by reviewing previous research on the internal firm characteristics of those firms that were early adopters and integrators of e-commerce. From the discussion on characteristics internal to the firm, four hypotheses are presented. Characteristics external to the firm, are also important factors in influencing whether or not a firm adopts e-commerce, and three hypotheses are presented relating to urbanization agglomeration and knowledge spillovers. A last group of hypotheses is introduced in chapter 2 that focuses on what happens to employees in the firm after e-commerce is adopted.

Chapter 3 presents the data and methodology used to test those hypotheses introduced in chapter 2. As the Census data utilized in this dissertation is strictly limited to those with Special Sworn Status in the U.S. Census Bureau, careful attention is given to fully explaining the combination of data selected, what each variable measures, and how they were coded when deviating from the raw Census data. Included in the Census data is the value of e-commerce sales for an establishment; the number of production and non-production workers in the establishment; establishment worker wages; establishment outsourcing costs; establishment exports; and an overall financial measure of the establishment. Additional, variables not included in the Census data are also introduced in chapter 3. Chapter 3 also presents the methodological issues confronted in this dissertation and the manner in which they were addressed. Lastly, chapter 3 provides an overview the two models and two areal scales selected for analysis in this dissertation.

Chapters 4 and 5 provide the results of the models and how these results should be interpreted. Through multivariate analysis I examine the influence of firm characteristics on the incidence and degree of engagement in e-commerce. These analyses for those firms engaged in e-commerce, allow me to develop generalizations on the importance (or conversely non-importance) of specific attributes which define a firm's structure and operations and the engagement in e-commerce. Chapter 4 specifically focuses on the results from the seemingly unrelated regression analysis, conducted on two scales--the county level and the economic area—and tests the first seven hypotheses in this dissertation.

Chapter 5 presents the three-stage least squares model which incorporates a more realistic presentation of the relationships between e-commerce, employment, and wages, by specifically focusing on what happens to establishment employees and their wages after e-commerce is introduced. The last chapter in this dissertation concludes the work presented in the previous chapters by suggesting new research directions, policy implications based on the quantitative results, and contributions to the economic geography literature.

Lastly, one important item that should be noted as the reader proceeds through this dissertation is the time period under analysis. 1999 was the first year that the Census Bureau began collecting data on the use of e-commerce in U.S. manufacturing and is therefore the first year of analysis for this dissertation. In 1999, e-commerce accounted to just over 10 percent of total sales. By 2005, the end of time period under analysis, e-commerce accounted for 26.7 percent of the total value of sales for the manufacturing industry. Therefore, the results and my interpretations are situated within the 1999-2005 timeframe and should be viewed with this lens. However, with the continued growth of e-commerce, I would argue that many of the findings and ideas implicit in this analysis remain relevant today and can provide useful insight to how the introduction of new technology affects the prospects for labor in established industries.[1]

[1] Since 2005, e-commerce in the U.S. manufacturing industry has continued to grow at an astounding pace, at least in terms of the total value of sales for the industry, to over 50 percent in 2012.

2. Technological Change and the Firm: Adoption and Infusion of E-Commerce in U.S. Manufacturing

Over the last 20 years, national economies and firms have become more interdependent. This process is indelibly linked to the presence of enabling technologies – transportation, communications and organizational innovations – that aid in the internationalization process (Dicken, 2003). Although capitalism has always been an international system, globalization has further expended firms' financial and economic flows to more spaces and places. The intensity of these integrated flows puts new constraints and demands on policy options (Dunning, 2002). The Internet has provided a new basis to conduct business and created complex linkages between and within firms (Barfield et al. 2003; McKnight 2001; Castells 2001; Tapscott 1999; Cronin 1996). Networks are affecting the economy in an unprecedented manner and cyberspace offers uniquely supple instruments to cultivate and deepen consumerism. The expansion of consumerism has particularly resonant geographic implications. Indeed, we may have entered an epoch of digital capitalism (Schiller 1999). Perhaps one of the most conspicuous indicators of this movement is the dramatic way in which IT and e-commerce in particular, has penetrated the fabric of economic activity.

While there has been much speculation about the impact and spatial organization of an increasingly networked society, it is only within the last 15 years that have we begun to see how IT can influence the ways in which people and firms react and respond to opportunities (Malecki 2004; Malecki and Moriset 2008; Van Geenhuizen 2004;

Kellerman 2002; Drennan 2002; Kotkin 2001; Leamer and Storper 2001; Zook 2000). One of these technological applications is e-commerce, which has existed since the 1970s, but which has become particularly conspicuous as more and more firms integrate it into their business model. As with previous technological applications, I argue that the integration of e-commerce into the business model of manufacturing establishments will alter the firm's business model, specifically in regard to the numbers of workers within the establishment.

The first part of this chapter reviews the academic literature on the relationships between technological change, its role in the capitalist economy and e-commerce. Most research published on e-commerce argues that it and the expansion of the Internet have not radically altered how the capitalist economy functions more broadly in the United States. Although the expansion of the Internet and e-commerce may not have fundamentally restructured the U.S. economy, it has had serious implications for workers impacted by its adoption and integration within the firm (Zook and Samers 2010). The second part of the chapter focuses on e-commerce adoption and the firm, reviewing previous research on the characteristics of firms that were early e-commerce adopters and how e-commerce adoption influenced firms and affected their workers once its associated technologies are integrated into the buying and selling process. Lastly, the nine hypotheses tested in this dissertation are also introduced.

Broadly, this chapter demonstrates:

- E-commerce adoption varies between manufacturing firms and sub-industries
- E-commerce adoption rates vary spatially
- The ways in which e-commerce is adopted varies, and these variances will impact workers and wages.

The Disruption of Technological Change, the Internet and E-Commerce

The capitalist economy creates and thrives off of uneven economic development over space and through time. It is considered dynamic in technological and organizational terms, where the search for profit inevitably demands that new and innovative ways for extracting value from labor be devised in the midst of a competitive environment. The search for new profit sources in the capitalist system generates and necessitates uneven development over space and through time as capital constantly shifts between regions in search of enhanced profits (Smith 1984). As the "perennial gale of creative destruction" capitalism and capitalist economies have historically been linked to technological advances, resulting in "technological unemployment" (Schumpeter 1942), where workers are shifted from obsolescent job markets and into newly created job markets. However, the shifts in "technological unemployment" today are not necessarily easy shifts into newly created jobs markets. Instead, many of the newly created job markets require sophisticated skills that the newly unemployed are unable to fulfill. And in some cases, new job markets may not be created and job positions simply no longer exist.

Historically, transformative developments in technology and their economic impact reshape the principles and operations of everyday socio-economic life (Martin 2006: 39). Advances in technology contribute to inequalities created by capitalist practices by enhancing worker productivity and altering the mix of products, industries, firms and jobs (Malecki, 1997). By creating upheavals in the industrial system and in producing persistently uneven geographical development (Storper and Walker 1989), the capitalist economy benefits some at the expense of others.[2] Capital investment in technology to substitute for or replace labor is nothing new. It was a common feature of the second Industrial Revolution, as the adoption of large-scale production and vertical integration became standard operating practice (Hugill 2003). The best example might be the automotive industry, which was perhaps the primary outgrowth of the second Industrial Revolution. Henry Ford's well-known production model sought to optimize the whole production system, including substituting machines for human labor (Hounshell 1984; Hugill 2003).

While it's true that Internet-related technologies are not ubiquitous, neither were prior commercial technologies, and the electronic sort of technologies might be easier to acquire for those without significant monetary coffers. The Internet seemed particularly promising in this regard because it could remove one of the barriers to success hindering enterprises in small or geographically isolated communities. Thus, many early

[2] However, before any discussion of how technology and technological progress change the economy can take place, there must be a clear understanding that technology itself does not cause any particular type of change. Rather, technology is an enabling or facilitating agent that makes it possible for new economic activities to occur (Dicken 2003; Coe et al. 2007). There are no pre-ordained inevitable economic outcomes that result (or will eventually result) across space and time due to technological implementations. Technological change does not progress in a linear manner, where different firms or regions are simply located at different points in the same path. Essentially, advances in technology are not deterministic--the technologies themselves do not cause various changes. Technology, itself, is not a cause for economic growth and development to occur (Massey 1999).

conceptualizations of the role of the Internet, envisioned it decreasing or eliminating the geographical distance between firms (B2B) and firms and consumers (B2C), thereby serving as a mechanism for rural and peripheral establishments to fully engage in the capitalistic market. According to Graham (1998):

> "there are widespread predictions that concentrated urban areas will lose their spatial 'glue' in some wholesale shift toward reliance on broadband, multimedia communications grids. Advanced capitalist societies are thus liberated from spatial and temporal constraints and are seen to decentralize towards spatial and areal uniformity" (168).

However, the Internet is far from being a spaceless or placeless phenomenon. Not all places are equally connected, and the process by which distant places are brought closer together by technological innovations is geographically uneven (Dicken 2011). Internet access has diffused unevenly within the economy as well, across firms and across individuals. Numerous productivity benefits currently being brought about through Internet use and implementation—such as increases in efficiency, productivity, speed of response, scope and breadth of market influences—convey only to those with the resources and the knowledge to take advantage of these opportunities (Gurstein 2003). Thus, the Internet has intensified, rather than eliminated the historic role of certain places as centers of specialist knowledge, information and power (Mackinnon and Cumbers 2007).

Three Types of Technology effects – Production, Friction, and Process?

Regardless of whether Internet-related technologies have wrought the utopian societal vision early pundits predicted, or instead have exaggerated inequalities, it is clear that they have wrought significant changes. Scholars have distinguished between two types of technology: (1) technologies that directly change the production process, and (2) technologies that help to overcome the friction of space and time, (Coe et al. 2007; Dicken 2003; Feldman 2000). Changes to the production process and the technological advances that can result in process innovations are generally introduced to reduce production costs and increase production efficiency. Although technological advances can enhance productivity, they also enable greater control over the production process which, among other things, has enormous implications for the volume and type of labor employed (Perez 1985). Rifkin (1995) argues that technological changes affecting production processes can cut employment. Dicken (2003) concurs, finding that technologies that change the production process adversely affected the availability of employment opportunities to less-skilled workers. Overall, previous research has shown that production process innovations tend to be labor-saving, rather than a source of new employment options.

However, discussions of technological impacts on the production process and employment are not directly relevant to this dissertation. E-commerce, as defined by the Census Bureau, is a part of the non-production side of the business process. E-commerce does seem a better fit for the second category—as a technology that helps overcome the friction of time and space—but business-to-business (B2B) e-commerce does not fit comfortably into that classification either, because it is more than a way to bridge space. E-commerce enables production changes based on improved communication about consumer needs—it is a process innovation. Process innovations refer to new production techniques that are applied to existing commodities. There are at least three forms of process innovation: (1) innovations that reduce production inputs, (2) innovations that improve working conditions, and (3) innovations that either solve a technical difficulty in manufacturing or improve a service (Armstrong and Taylor 2000: 286). E-commerce falls into the third category because it improves a service, however, backward linkages of e-commerce such as supply procurement and the substitution of e-commerce for labor can reduce production input costs. Because process innovations focus on incorporating new technology into production methods (Feldman 2000), they are frequently introduced to lessen production costs and increase productive efficiency.

As this discussion above demonstrates, e-commerce has the potential to alter the economic landscape significantly for both firms and workers. But not all firms will adopt e-commerce, and among those that do, the level of e-commerce integration within the firm will vary. Determining which characteristics encouraged firms to be early adopters of e-commerce is significant, because it provides insights into how manufacturing industries will develop and change over the next 10-20 years—at least, if we assume that e-commerce adoption trends in manufacturing continue at the exponential growth rates seen over the last decade.

E-Commerce and Firm Adoption

Cost reductions and efficiency increases are two interrelated motivations for why firms adopt e-commerce (Daniel and Grimshaw 2002; Bresnahan et al. 2002). Cost savings for firms can be generated via e-commerce through both the buying and selling of materials. One mechanism to generate cost savings is through price reductions in materials purchased, because establishments can acquire these more cheaply when they access a greater number of suppliers online (Porter 2001). Setting up electronic product exchanges with buyers can also streamline the selling process, creating a more efficient system (Kraemer et al. 2005). Automating the buying and selling of products between businesses can also reduce a firm's costs by cutting the number of employees needed to conduct these exchanges. Although the search for cost savings via e-commerce does not necessarily imply a reduction in employees, it is one way to reduce labor inputs.

Firms are also motivated to adopt e-commerce because it lets them expand their market reach and engage with a more spatially dispersed customer base (Poon and Jevons 1997; Hamill and Gregory 1997; Bayo-Moriones and Lera-Lopez 2007; Daniel and Grimshaw 2002). Expanding global market reach and finding new customers overseas is a critical motivating factor for Small- and Medium-Size Enterprises in their efforts to level the playing field with larger competitors. Using e-commerce to alter and or create new and/or enhanced value in their production and distribution chains has clear implications for the type of economic activities in the places where these firms are headquartered as well as elsewhere (Gurau et al. 2001). And widening the geographical market place and bringing more companies into competition with one another has a circular effect of forcing firms to seek significant cost reductions and efficiencies to remain competitive.

Firms seeking the benefits described above do so in the pursuit of better financial performance. Cost reductions, increased efficiency, and expanded market reach are all factors implicated in boosting financial performance. Market impacts, efficiency impacts, and cost reductions through increased coordination between buyers and sellers positively influence a firm's financial performance and motivates' them to adopt e-commerce (Kraemer et al. 2005). The implementation of e-commerce activities assists firms in establishing a competitive advantage over competitors, although it is unclear whether e-commerce will lead to a sustained competitive advantage (Barney 1991).

Understanding why firms in the capitalist economy adopt e-commerce provides a theoretical rationalization to identify the characteristics of the firms that were early e-commerce adopters. Combining these theoretical underpinnings with previous research on the topic leads to the following seven hypotheses. Each of these relates to the internal and external factors to the firm that prompt e-commerce adoption. The first four hypotheses evaluate characteristics internal to the firm. Hypotheses 5-7 evaluate characteristics external to the firm such as physical rural vs. urban location and two contextual variables evaluating the role of knowledge spillovers from an urbanization perspective and an industrial perspective. Lastly, two additional hypothesis statements are included that determine the effects of adopting e-commerce on workers and worker wages.

Characteristics Internal to the Firm: Firm Size, Exports, Outsourcing, and Wages

Firm Size

Firm size has been identified as a key factor in e-commerce implementation and is one of the most discussed firm characteristics (Shen et al., 2004; Daniel and Grimshaw 2002; Kraemer et al. 2005; Dasgupta et al. 1999; and Kaun and Chau 2001). Early theorizations of the internet and e-commerce argued that these new technologies would empower smaller establishments to develop global marketing campaigns that previously would have been unaffordable (Poon and Jevons 1997). Small- and medium-sized establishments would reach new and more spatially distant customers, thus leveling the competitive playing field with larger establishments (Grandon and Pearson 2004). However, empirical analysis has not borne out these predictions. While, theoretically, e-commerce adoption should benefit small and medium sized enterprises—given that it provides a low-cost means to compete globally (Cuadrado-Roura and Garcia-Tabuenca, 2004; Auger and Gallaugher 1997)— smaller firms (particularly from non-technology sectors) may be reluctant to be among the early adopters of e-commerce due to uncertainty over its financial benefits (Fillis et al. 2004).

Most studies on e-commerce adoption have verified that larger firms adopt and integrate e-commerce activities at higher rates than smaller establishments (Tan and Teo 1998; Teo 2007; Fruhling and Siau 2007; Van Beveren and Thomson 2002; Granson and Pearson 2004). Larger firms can more readily adopt e-commerce because of their ability to access larger pools of human and financial resources. Thus, structural characteristics affect a firm's ability to adopt new innovations (Bayo-Moriones and Lera-Lopez 2007).

E-commerce being adopted predominantly by large establishments, as opposed to small and medium sized establishments, may be worrisome given the important economic role modestly sized firms play in the U.S economy. Small- and medium-sized enterprises are critical to the overall health of the economy. According to the Small Business Administration; "small business is critical [to the United States'] economic recovery and strength, to building America's future, and to helping the United States compete in today's global marketplace" (US Small Business Administration 2008). Small-and-medium-sized enterprises are critical because they occupy an economic niche that is underserved by larger establishments. They are in an advantageous position to provide services that multinational corporations are unable too because of the opportunity costs involved (Dana 2006).

Establishing that larger firms were among the early adopters of e-commerce is not surprising given the resources (funding and labor pools) they have at their disposal. Having a large workforce to draw human capital from and the ability to devote more resources to technological innovations may lead to efficiencies in the long run. Advances in information technologies are important if workers have the skills to apply these technologies to their various activities. Numerous studies have verified that firms with highly skilled employees are better equipped to adopt new technologies because their skills enhance their use and impact (Arvantis 2005; Bresnahan et al. 2002; Fabiani et al. 2005; Falk 2005; Lucchetti and Sterlacchini 2004; Morgan et al. 2006; Perez et al. 2005; Bayo-Moriones and Lera-Lopez 2007).

Because previous research has consistently demonstrated that larger establishments tend to be the adopters of e-commerce, I expect to find a similar relationship. However, there are several ways that establishment size can be measured and (in the context of this dissertation) different ways to theoretically interpret "size." Typically, an establishment's size is measured by the number of people it employs. The number of employees may be related to an establishment's e-commerce usage because they have a larger employee pool from which to draw certain expertise. Establishment size may also be an important characteristic because it reflects the specific type of employees within an establishment. Larger firms, on average, have more administrative employees than a smaller firm, so it is more likely that the establishment will already have trained administrative employees to implement high-tech solutions. Another measure of an establishment's size is its yearly revenues. Revenues indicate the monetary resources that an establishment can allocate to the necessary products and employee training needed to maintain an on-line presence. Irrespective of how establishment size is measured, however, the following hypothesis is proposed:

Hypothesis 1: Large U.S. manufacturing establishments will have higher rates of e-commerce adoption

Exports

Expanding market reach has been discussed in the literature as one factor that motivates a firm to adopt e-commerce. Using survey data, Daniel and Grimshaw (2002) assess the relationship between firms and their orientation toward exporting products. They questioned firms on whether e-commerce adoption was attractive because it opened up opportunities to access global markets. Their findings suggest that small-and-medium-size enterprises are more likely than larger firms to implement e-commerce activities to expand their market reach. These findings are consistent with research on exports and firms, as other studies have shown that small-and-medium-sized enterprises previously restrained from international trade due to both internal and external resource limitations benefit from e-commerce (Poon and Swatman 1997).

The Internet and e-commerce open up low-cost options to help small-and-medium-sized enterprises overcome many international trade barriers. Hornby et al. (2002) surveyed 74 small-and-medium-size enterprises in Australia and found that although companies perceived export barriers to be lower using online systems, they had not extended their export philosophies to their online domains. Essentially, the surveyed firms expected their websites to reach global markets but not to replace the need for foreign representation or branches in those markets. Although the Internet and e-commerce offer a low-cost resource for firms to expand their export market, there is more to the relationship than merely setting up a website.

More recent research evaluates the linkage between e-commerce and a firm's export marketing strategy (Gregory et al. 2007). Gregory et al. (2007) determine that e-commerce has a direct effect on a firms marketing strategy and that firms are more successful at achieving a sustainable competitive advantage if the integration of e-commerce is carried out in a customized manner that enhances or strengthens the firm's strategic position in the export market. But as Porter (2001) notes, although e-commerce can expand markets it often results in lost profitability when existing information asymmetries favoring established firms are whittled away. Hence, the following hypothesis is proposed:

Hypothesis 2: Exports will be higher among U.S. manufacturing establishments that use e-commerce.

Outsourcing to Contract Labor

The use of contract labor in the manufacturing industry has grown over the last 30 years. Firms commonly outsource aspects of the production process, which enables them to focus on product design, development, or marketing (Plambeck and Taylor 2005). Contracting out some activities along the vertical chain of production allows firms to focus on other activities that may offer the firm a comparative advantage. Firms may also outsource service activities, such as communication and information technology services. Usually this is done so a firm can strengthen its core competencies (Chongvilaivan et al. 2009). It is probable that firms which outsource facets of their production or non-production processes have a more sophisticated grasp of coordinating communications between entities internal and external to the firm. Experience managing and coordinating communications between a firm and its external contractors should provide for easier adoption of e-commerce activities, hence:

Hypothesis 3: E-commerce adoption will be higher among establishments that outsource parts of the manufacturing process to contract workers.

Wages

On average, highly skilled workers earn higher wages than lower-skilled employees in the manufacturing industry (Matano and Naticchioni 2012; Goldin and Katz 1999). Wage disparities that have emerged between high skill and low skill workers in the manufacturing industry has been attributed to "skill-biased technological change" by researchers, despite some contentiousness over this assertion.[3] Work by Brown and Campbell (2001) determined that "information-handling automation" was a first-rate example of a skill-biased technological change, however, their research did not identify a corresponding change in wages. Although there are similarities between e-commerce and job tasks that involve "information-handling automation," e-commerce encompasses far

[3] Several researchers have attributed the rise in wage dispersion to institutional changes and globalization, rather than skill-biased technological change. See Baldwin and Cain (1997) and Leamer (1996).

more than the automation of information.

Although previous research has not determined exactly what effect e-commerce usage has on the wage rates of an establishment's administrative employees, several quantitative studies have demonstrated a correlation between advances in information technologies and worker skills (Bresnahan et al. 2002; Krueger 1993). E-commerce in this dissertation pertains to the buying and selling of goods over electronic networks. The shift toward buying and selling goods over networks—tasks that had traditionally been reserved for administrative employees—should impact the wages of individuals working in this capacity at firms that adopt e-commerce. Because administrative employees directly engage in buying and selling products, they are responsible for ensuring that products are exchanged between buyers and sellers. Thus, manufacturing firms may also have to pay higher administrative employee wages to ensure that they attract and retain workers with the ability and skills to coordinate the exchanges across electronic systems. As such, the following hypothesis is proposed:

Hypothesis 4: E-commerce adoption will be higher among U.S. manufacturing establishments that have higher wage rates for workers.

Characteristics External to the Firm: Urbanization and Knowledge Spillovers

While analyzing the internal characteristics of firms is one way to evaluate which firms were early adopters and integrators of e-commerce, there are also significant factors *external* to the firm with the potential to contribute to levels of e-commerce integration and adoption. Where firms are situated with respect to other and/or similar industries, infrastructure availability, and labor markets, has the potential to generate positive spatial externalities. Due to the externalities resulting from agglomeration economies, it is expected that e-commerce adoption rates will be higher among firms that are (1) located in close spatial proximity to many other firms that have or are in the process of implementing e-commerce solutions (urbanization agglomeration), or (2) are a part of the same industrial sector where e-commerce strategies are implemented (knowledge spillovers).

Theories of agglomeration generally hold that location is a key factor affecting the economic performance of both individual firms and the wider regions they are situated in (Marshall 1890; Abdel-Rahman and Fujita 1990; Feser 2001; Duranton and Puga 2004). By locating in large, dense urban areas where key inputs, such as labor and transportation infrastructure, are abundant, firms are able to improve their productivity and competitive advantage vis-à-vis firms in other, less advantageous localities (Koo and Lall 2007). Or, as Atrostic et al. (2000) argue, "[c]hanges in the characteristics of individual businesses could lead to changes in the characteristics of broader economic entities of which they are a part, such as industries, sectors, and countries." Scholars have identified two distinct (although overlapping and related) types of agglomeration economies: (1) urbanization economies and (2) localization economies (Coe et al. 2007; Feser 2001). In both instances, the impacts of agglomeration reflect the insight that the operations of one firm or establishment generates positive externalities for other companies operating within the same geographical space.

Urbanization economies are defined as those that emerge from the clustering together of activities in cities. This clustering establishes the possibility of sharing the costs of infrastructure and services between firms as well as opening up access to larger markets. Localization economies, on the other hand, refer to a situation when firms *in the same or related industry* that locate in the same place, and in doing so accrue significant cost savings (MacKinnon and Cumbers 2007). Scholars in economic geography have tended to focus on localization economies because they are central to the dynamics of agglomeration in a post-Fordist context (Coe et al. 2007). However, both types of agglomerative economies tend to generate endogenous positive spatial externalities that can be leveraged by firms (Fujita et al. 1999). Positive spatial externalities accrue to firms and workers alike located in close spatial proximity due to knowledge spillovers, thick market effects in the labor market, proximity to consumers, inter and intra-firm networks, institutional thickness, and cost reductions (Patacchini and Rice 2007; Scott and Storper 2003; Coe et al. 2007; Koo 2005; Duranton and Puga 2004).

Urbanization/ Rural vs. Urban

I anticipate that e-commerce will reinforce the positive spatial externalities generated through both urbanization and localization economies. As Internet access has spread throughout the United States, it has created new opportunities for firms in urban and rural areas to participate in e-commerce. Early theorizations of internet diffusion suggested that the internet would level the competitive playing field for firms and industries located in rural areas, however, these ideas were largely premised on the same faulty assumptions proposed by the 'death-of-distance' theorists discussed previously. These early theorizations held that firms in rural areas would be able to communicate instantaneously with counterparts located at a great distance, which in turn would let them reach new customer bases at lower costs than was previously possible.

As mounting evidence has demonstrated, it is highly unlikely that the Internet, and e-commerce more specifically, will serve as the conduit for eliminating the economic hierarchy between urban and rural areas, especially in the United States (Malecki and Gorman 2001; Garcia 2002). Thus, although e-commerce adoption by firms in rural areas provides a clear benefit relative to not implementing e-commerce, these advantages do not overcome the potential value created by the positive externalities of agglomeration in urban areas, especially when such advantages are coupled with the adoption of e-commerce by urban firms. Early research in e-commerce has demonstrated that firms in urban areas adopt e-commerce at a higher and faster rate than firms in rural areas. Although Cuadrado-Roura and Garcia-Tabuenca (2004) and Sambrook (2003) emphasize the sizable marginal benefits that e-commerce offers rural firms, they also note the paradox that firms in these locations, for reasons of capabilities or education, are among the slowest to adopt these new technological innovations. Moreover, Van Geenhuizen (2004) argues that the high levels of uncertainty associated with continuing changes in e-commerce make cities important strategic locations (Porter 2001). Lastly, given that information technology and e-commerce, tends to reinforce agglomeration rather than weaken it (Glaeser 1998; Polese and Shearmur 2006), the following hypotheses are proposed:

Hypothesis 5: E-commerce adoption will be higher in urban areas than rural areas.

Hypothesis 6: E-commerce adoption will be higher among establishments that are co-located near other establishments using e-commerce.

Knowledge Spillovers

While agglomeration economies can be subdivided into both urbanization and localization economies, the positive spatial externalities generated by agglomeration economies can be disaggregated into two separate concepts: traded and untraded interdependencies (Storper 1997). First, traded interdependencies emerge when firms in close spatial proximity have a formal trading partnership with one another. By co-locating in the same space, firms reduce transaction costs and can achieve a greater level of flexibility in production (Piore and Sable 1984; Scott 1993). These interdependencies are connected to the more general idea of agglomeration, suggesting that firms benefit from the lower costs of production generated by operating in close proximity to other firms (Malecki 1997). Localization agglomeration is, therefore, a principle source of the productivity-enhancing outcomes that result from the positive externalities generated from spatial proximity.[4]

Untraded interdependencies can also arise through localization agglomerations. Firms may co-locate because they can potentially tap into a larger pool of skilled workers (Helsley and Strange 1990). Firms that require specialized workers, but incur challenges due to major shifts in product design, need access to large pools of specialized talent to smooth out the unevenness of the production process (Scott and Storper 2003). Workers also have strong incentives to specialize their talents because with specialized skills they

[4] Agglomeration economies also generate negative externalities, which is one explanation for why every firm and worker does not locate in one super urban area (Polese and Shearmur 2006).

can command higher wages and be more productive (Glaeser et al. 1992; Ciccone and Hall 1996; Combes 2000; Rosenthal and Strange 2004). Specialized labor pools may form in agglomeration economies because they reduce workers' risk of unemployment—individuals will have a larger market to sell their labor in.

These kinds of untraded interdependencies are both facilitated by, and are the result of, intra- and inter-industry networks of knowledge transfer that are focused on the technological and organizational processes of firms (Glaeser et al. 1992; Malmberg and Maskell 2006; Malmberg and Maskell 2002). One specific way of understanding untraded interdependencies is they represent the less tangible benefits of being located in the same place (Storper 1997). This encompasses the concept of knowledge spillovers. Knowledge spillovers stem from increasingly complex information exchanges during the course of economic exchange and the imperative for firms to co-locate in order to maximize the frequency, intensity and efficiency of interpersonal, inter-firm and inter-industry communications (Malecki 1997:150; Leamer and Storper 2001; Gaspar and Glaeser 1998; Glaser and Mare 2001; Zook 2005; Glaeser and Ressenger 2010).

While knowledge spillovers between firms in the same region can pertain to any number of topics, the key area of inter-firm knowledge transfer this research is concerned with is the decision to adopt information and communication technologies (Bayo-Moriones and Lera-Lopez 2007). Hypotheses proposed by Bayo-Moriones and Lera Lopez (2007) suggest that the industrial sector that an establishment operates in, as well as their geographic location, may influence a firm's technology adoption process. Their results demonstrate that the adoption of new technologies is lower in the building and agricultural sectors compared to other industries such as manufacturing and services.

Unfortunately, the authors offer no insight as to why these business sectors utilize information technologies at lower rates then the manufacturing and service industries. They merely indicate that the outliers should be analyzed more in-depth.

While researchers have yet to determine whether the industrial sector an establishment operates in specifically influences the technological adoption in those establishments, it is reasonable to assume that different industrial sectors have different technological needs. This may also be the case for the various subsectors categorized as "manufacturing." Data collected by the U.S. Census Bureau has demonstrated that within the manufacturing industry, five industries account for over 70 percent of the value of e-commerce sales. Given that the core value of e-commerce shipments in manufacturing is concentrated within five manufacturing sectors, establishments operating in these sectors may feel pressure to adopt e-commerce activities.

Although the economic geography literature generally views knowledge spillovers as a product of localization agglomerations, Bridge and Wood (2005) point out that the direct association between localization economies and knowledge spillovers is unwarranted and that technological change is de-territorializing some types of knowledge. I anticipate that this is the case for firms operating in manufacturing subsectors where e-commerce adoption is widespread, suggesting that industrial specific knowledge spillovers can move beyond the local and/or regional area. Essentially, once a technology becomes so integrated into the fabric of that industry then its adoption by others may become more or less essential to ensure survival. Hence, the following hypothesis is generated:

Hypothesis 7: E-commerce adoption will be higher among establishments in industrial sectors where e-commerce adoption is also high.

Human Capital and the Firm

Research on e-commerce adoption and its effects has not been limited solely to the internal and external characteristics of different firms and establishments. Along with this work, there exists a significant body of research on the role of human capital and information technology adoption. This research focuses on the importance of individual workers and their skills to information technology development and adoption. It acknowledges that without the requisite skills embodied in the workforce to take advantage of such innovations, the adoption of new technologies will provide scant benefit. Numerous studies have verified that highly-skilled workers make technological adoptions easier, as their skills enhance the usage and impact of these technologies (Arvantis 2005; Bresnahan et al. 2002; Fabiani et al. 2005; Falk 2005; Lucchetti and Sterlacchini 2004; Morgan et al. 2006; Perez et al. 2005; Bayo-Moriones and Lera-Lopez 2007). If technology adoptions are made easier by the presence of more highly skilled workers, it seems probable that establishments adopting e-commerce activities will employ more highly skilled workers.

On average, highly skilled workers tend to earn higher wages than those with fewer marketable skills. This trend has been evident in the U.S. manufacturing industry as well as the general economy since the 1980s. The widening gap between skilled and unskilled labor has been attributed to international outsourcing, skill-biased technological change, and more recently, a structural shift in the sectoral composition of the economy

(Chongvilaivan et al. 2009). However, these studies tend to focus on the wage gap between skilled and unskilled production workers. It is unclear what type of effect e-commerce use has on the wage rates of the establishment's non-production workers. Since e-commerce in this dissertation only pertains to the buying and selling of goods over electronic networks—the tasks directly performed by non-production employees—it seems likely that the use of e-commerce should affect firms' wage rates as well. As non-production employees are the workers who directly engage in the buying and selling of products, they are responsible for ensuring that products are exchanged between buyers and sellers. Essentially, manufacturing establishments may also have to pay higher administrative employee wages to ensure that they attract and retain skilled workers that are able to coordinate exchanges across electronic systems.

E-commerce use in manufacturing establishments may also affect the overall number of employees at a firm. According to the Bureau of Labor Statistics (BLS 2012), the number of workers in manufacturing declined significantly from 1999 to 2006. While employment in the U.S. manufacturing industry has declined steadily over the last 30 years, the year 2000 marked the beginning of a new significant downturn in U.S. manufacturing employment. Significant employment losses in manufacturing were seen after the relatively mild recession of 2001, with 1.5 million jobs lost during the first year of the recession. In comparison, during the first year of the Great Recession (December 2007 to June 2009) approximately 600 thousand fewer manufacturing jobs were lost (Pierce and Schott 2012). While it may be a coincidence that this significant decline in manufacturing jobs coincides with the rise in e-commerce, these two incidents may be related. As information technologies are implemented, firms may reduce the number of administrative workers required to accomplish the buying and selling of products, while at the same time retaining or increasing the number of production workers employed

The relationship between e-commerce, employment, and wages is complex. Earlier research has suggested that there is a relationship between e-commerce adoption and a firm's access to human and financial resources (Bayo-Moriones and Lera-Lopez 2007). Although the initial decision of whether or not to adopt e-commerce activities within a firm may initially depend on its human and financial resources, once the firm establishes and implements e-commerce, it is believed that this relationship is more circular than implied by a simple cause and effect model. A firm's number and type of employees affects its e-commerce intensity, while simultaneously the level of e-commerce intensity adapted by the establishment is likely to affect the number and type of employees needed after the initial adoption. I also anticipate that as establishments adopt e-commerce activities, worker skill sets will necessarily change. Workers will be required to learn new skills as e-commerce technologies continually change and evolve. Current employees may be required to complete continuing education courses, while new hires may have more technical educational backgrounds. Given the advanced skill sets and the higher level of education among workers at establishments that adopt e-commerce, it is expected that those establishments will pay higher worker wages.

Therefore, a further set of hypotheses will be used to help me gauge how the adoption of e-commerce alters the labor structure of the establishment and its employee's wages. I anticipate that once an establishment has implemented e-commerce, it will exhibit significant changes in the total number of workers employed, the type of workers employed, and employee wages. Understanding how e-commerce affects the organizational structure of manufacturing establishments can provide insights on future employment in manufacturing, such as the type of worker likely to benefit and how employee wages will be affected Changes related to employment levels and wages are integral to any national or regional economic development policy. The following two hypotheses are proposed:

Hypothesis 8: After e-commerce adoption the total number of employees in an establishment will decrease.

Hypothesis 9: After e-commerce adoption, employee wages will increase as more highly skilled employees will be needed to implement e-commerce technologies.

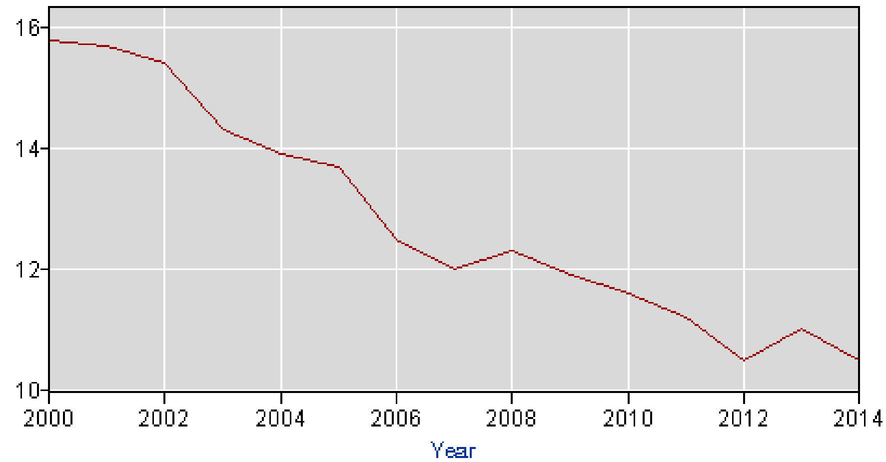
Testing the Hypotheses

The nine hypotheses presented above are tested in chapter 4 and chapter 5. The first seven hypotheses are tested using a seemingly unrelated regression model that predicts the relationship between the variables of interest and several other control variables. However, the seemingly unrelated regression model can only evaluate how the variables of interest predict e-commerce intensity within a manufacturing establishment (see chapter 3). A second model is introduced in chapter 3 that is designed to explore relationships between e-commerce intensity, establishment employment and establishment wages (see Hypotheses 8 and 9). The second model, a three-stage least squares provides the opportunity to evaluate more realistic relationship between these variables by answering questions about what happens to employees and their wages after e-commerce is adopted within the establishment.

Unfortunately, there are several key questions related to this research that I am unable to address. One significant area involves the role of local and regional institutions and how they link the economic and the social behaviors of economic actors through habits, practices, and routines (Hodgson 1993). The "embedded" social relations that are ingrained in specific places, was a concept that I could not distill into a single numerical value. Based on the research behind these important ideas, I suspect that if a numerical measure had been available, it would have further refined my models with respect to the geographic scale for knowledge spillovers. Currently, I only measure knowledge spillovers among industries.

I was also unable to include a measure of unionization in this research. Certainly, there is a relationship between manufacturing employees represented by unions and wages, but union data at the county or economic area level is not publically available. Union data is also not included in the data available from the U.S. Census Bureau. The Bureau of Labor Statistics does provide a yearly measure of the percentage of employed, wage and salary workers, represented by unions in the U.S. Manufacturing industry. The yearly averages demonstrate a continual decline in union affiliation from 2000 to 2014, from 15.8 percent of workers in manufacturing being represented by unions in 2000 to 10.5 percent in 2014. Please see Table 2.1 below:

Figure 2.1: Percent of Employed Manufacturing Workers Represented by Unions 2000-2014



Source: United States Department of Labor, Bureau of Labor Statistics

For the years under analysis in this dissertation, the percentage of union membership decreased from 15.8 percent in 2000 to 13.7 percent in 2005 (Bureau of Labor Statistics 2014). Given the decreasing numbers of manufacturing employees that are union members, I suspect the role of unions is not a critical as it would have been when union membership was more dominant.

Although my inability to include a measure of institutional embededdness and unionization--due to the lack of available data--is a drawback, the results from the models included in this dissertation are still valuable for analyzing the hypothesized relationships included in the above chapter.

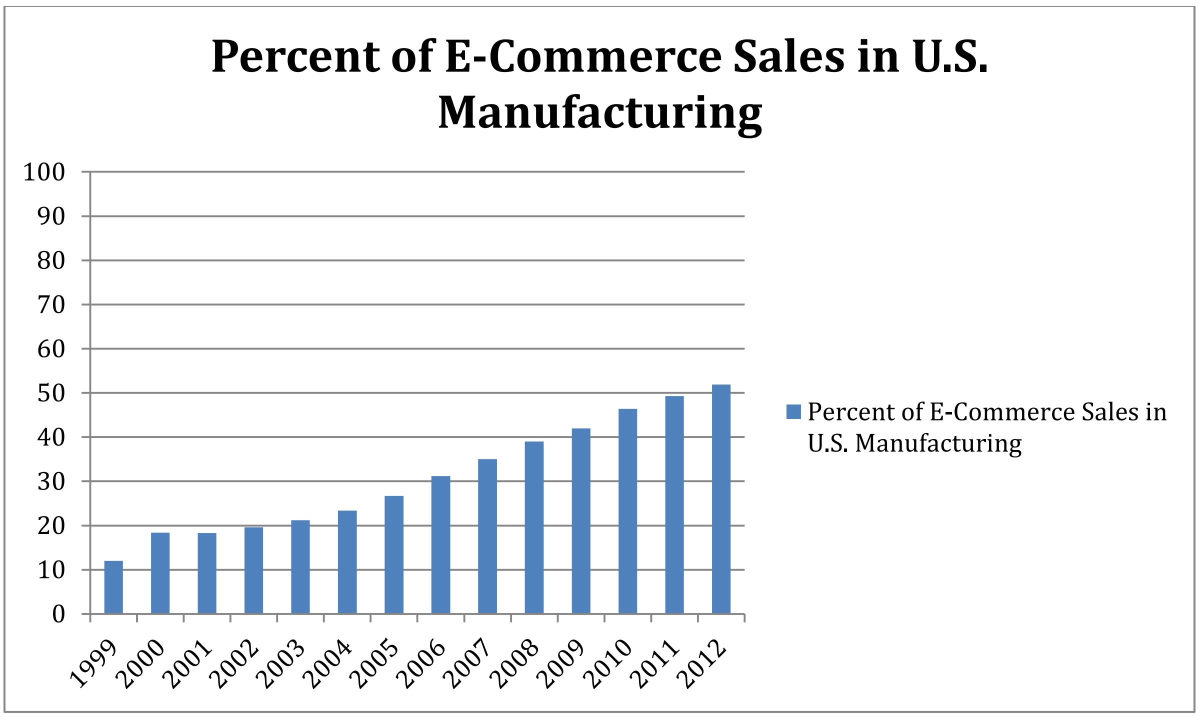
3. Data and Methodology

The hypotheses introduced in the previous chapter were presented to provide insight to how e-commerce adoption and utilization change the condition of U.S. manufacturing establishments, by answering two interrelated questions (via two models): (1) What are the characteristics of manufacturing establishments that were early adopters of e-commerce activities?; and (2) Once e-commerce is adopted, how has e-commerce intensity affected labor wages and total employment within manufacturing establishments? The first seven hypotheses in the previous section directly address establishment characteristics for firms that were early adopters of e-commerce. Hypotheses eight and nine address how labor in manufacturing establishments changed after e-commerce was adopted. The following chapter presents a description of the data utilized in this dissertation, the methodological choices made to produce valid and reliable estimates, and the methodological weaknesses to my approach.

Description of the Data

Although many definitions of e-commerce have emerged over the last 15 years this dissertation relies on the definition provided by the U.S. Census Bureau given that my research draws principally from its data. The Census bureau defines e-commerce as "Any transaction completed over a computer-mediated network that transfers ownership of, or rights to use, goods or services" (Atrostic et al. 2001). Although this definition is very broad, it is the definition that manufacturing establishments operationalize when they report data to the Census Bureau. Aside from the importance of manufacturing as outlined in chapter 1, historically, manufacturing has been and continues to be the sector of the economy in which e-commerce is most widely adopted (U.S. Census, 2013). Figure 3.1 shows the proportion of e-commerce sales in the U.S. manufacturing industry from 1999 to 2012. During this time period, e-commerce sales experienced an average annual growth rate of 14 percent per year over the 13 year period from 1999 to 2012, marking a steady upward trend. In 2012, e-commerce sales accounted for over 50 percent of total sales in the U.S. manufacturing industry, for a total of $3 trillion in sales.

Figure 3.1: Percent of E-commerce Sales in U.S. Manufacturing from 1999 to 2012



Source: compiled from U.S. Census Bureau E-Stats data: http://www.census.gov/econ/estats/

This dissertation relies upon two models. *Model 1* uses a seemingly unrelated regression (SUR) model (methodology explained later in this chapter) to determine what are the characteristics of manufacturing establishments that were early adopters of e-commerce activities? *Model 2,* uses a three-stage-least squares methodology to answer the second question of interest to this dissertation—which is--once e-commerce is implemented, how does e-commerce intensity affected wages and total employment?

Both of the models I developed for this dissertation were primarily sourced by data that the U.S. Census Bureau collects and maintains. For each year ending in 2 and 7, the Census Bureau gathers establishment-level data from every manufacturing establishment operating in the U.S. These data are not focused purely on e-commerce activity; it also includes information about employment payroll, the division of employment, operating costs and expenditures, the value of inventories and shipments, and the amount of product movement coordinated over electronic networks (U.S. Census Bureau 2007). The manufacturing data collected by the Census Bureau is assembled from the individual establishment, not at the level of the firm or enterprise. Census defines an establishment as: "A business or industrial unit at *a single location* that distributes goods or performs services." Therefore, it is not necessarily identical to a company or enterprise, which may consist of one or more establishments. The Census Bureau defines a firm as "A business organization or entity consisting of one domestic establishment (location) or more under common ownership or control. All establishments of subsidiary firms are included as part of the owning or controlling firm" (U.S. Census Bureau 2015). By focusing on the manufacturing establishment, I am able to capture the geographical distribution of the establishment's commercial activity, rather than just the amount by the entire firm or corporation.

The Census Bureau also conducts a yearly survey of manufacturing establishments; the establishments chosen for this survey are randomly selected from the

Manufacturing Economic Census. Organizations selected for the panel are required to participate in the Annual Survey of Manufactures (ASM) during a five-year period between each Manufacturing Economic Census. Over this period they are required to submit the same data that is collected for the Manufacturing Economic Census. As such, longitudinal data is available for a group of randomly selected establishments.

Beginning in 1999, the Census Bureau included the Computer Network Use Supplement (CNUS), a supplemental survey with the ASM.[5] The CNUS survey sought more granular e-commerce usage data from these establishments regarding the critical activities they perform using e-commerce. For example, the CNUS asked whether businesses used e-commerce platforms to purchase products; sell products to other establishments; and assist with production management, logistical operations, and communications or support services (U.S. Census Bureau 1999). The CNUS provides a good baseline measure of the level of e-commerce usage at a time when many manufacturing establishments had just started investing in e-commerce. The combination of the 1999 CNUS and 1999 ASM data, the 2003-2005 ASM panel data, and the 2002 CMF, provides a reliable longitudinal measure of the characteristics that predicted early adoption of e-commerce as well as for how e-commerce implementation changes an establishment's operational profile.[6]

In addition to the establishment-level data provided by the Census Bureau, the models include additional variables from the Bureau of Economic Analysis (BEA), the Federal Communications Commission (FCC), and the United State Department of

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[5] Example ASM, CNUS, and CMF surveys are included in the Appendix.

[6] Data from the 2000 and 2001 ASM were not included in the analysis for different reasons. The 2000 data was not included because the Census Bureau determined that the supplemental ASM survey was sent to the wrong company experts and was therefore completely unreliable. The e-commerce data contained in the 2001 ASM survey was not released by the Census Bureau for unknown reasons.

Agricultural (USDA). For *Model 1*, these variables provide a variety of measures at the scale of the economic area and county level, including a measure of broadband competition and the degree of urbanization of the establishment location.

The data used in the models are *confidential versions* of the Census Bureau's Census of Manufacturing (CMF), the AMS, the Longitudinal Business Database (LBD), and the Standard Statistical Establishment List (SSEL). Access to these data are regulated by Title 13 and Title 26 of the U. S. Code, meaning researchers desiring access must follow lengthy procedures to use the data (Kinney et al. 2011). Currently researchers can only access it at one of several Census Bureau Research Data Centers (RDCs) and gaining restricted access requires a rigorous vetting process and requires travel to conduct research. Research for this dissertation specifically required multiple trips to Chicago. The majority of time spent at the RDC was consumed by organizing the raw census data such that it could be analyzed. Data not housed within RDC (12 variables included in these analyses), required additional vetting and paperwork for each. Examples of this process are included in Appendix D.

The dataset for 2002 CMF contained over 300,000 data points – as 2002 is a year the Census Bureau collects survey data from all manufacturing establishments in the U.S. For the years 1999, 2003, 2004, and 2005, the ASM provided manufacturing survey data for the subset of establishments included in each panel. For each year, the ASM data contains over 30,000 observations. Given that the two datasets necessary to create a longitudinal data contained an unequal number of observations across the entire time period, I selected a subset of panel data to include in the models.

Creating a subset of panel data for the years 1999-2005 limits the number of observations that can be included in this analysis. However, incorporating a time-series component justifies losing a significant number of yearly observations as it provides an opportunity to look at the behavior of the panel of establishments over a specific time period. It also provides an opportunity to model how e-commerce adoptions changed establishments. Yearly data would not be able to answer these more interesting questions. Therefore, this data subset contains only establishments that were included in the panel every year. This eliminates all establishments that opened after 1999, failed between 1999 and 2005, or continued in operation but were not included in both the 1999 ASM survey group and the 2003-2005 ASM survey group. Due to the methodology the Census Bureau uses to select what establishments to include in the ASM survey group, the selection method excludes small plants from the sample.[7]

To combine the datasets, I used establishment-level identifiers such as the Employer Identification Number (EIN), the Permanent Plant Number (PPN), and the Census File Number (CFN). The primary identifier that I used to create the dataset was the PPN. For those businesses missing the PPN identifier, they were matched using the CFN. Lastly, establishments were matched using the EIN. The methodology used to link the data across the various datasets follows the methodology outlined by Jarmin and Miranda (2002).

Table 3.1 and 3.2 provide an overview or reference table of all variables included in *Model 1* and *Model 2*, including variable names, a brief definition of each variable, and the source of the data.

[7] Smaller plants in the ASM panel are intentionally replaced when a new panel is selected to reduce the reporting burden on those establishments (Dunne and Roberts, 1993). The years utilized in this analysis are drawn from the ASM panels for years 199, 2002 and 2003-2005.

Table 3.1: Variables included in *Model 1*

Variable Name	Variable Definition	Source
Establishment E-commerce Sales	Total e-commerce sales by establishment	ASM Survey
Establishment Outputs	Financial measure of establishment importance	ASM Survey
Establishment Employment	Total number of employees in establishment	ASM Survey
Number of Non-Production Establishment Employees	Non-production employees are those involved in factory supervision, sales, sales delivery, clerical and routine office functions, shipping, and record keeping among other non-production activities	ASM Survey
Establishment Salaries and Wages	The gross earnings paid in a calendar year to employees (measured in thousands)	ASM Survey
Establishment Exports	All exports that will be directly exported. Does not include items that will be further manipulated prior to export (measured in thousands)	ASM Survey
Establishment Outsourcing Costs	The total payments made during the year for contract work done by others on materials furnished by the establishment (measured in thousands)	ASM Survey
E-commerce Intensity by County	E-commerce sales (by county) divided by TVS (by county) to determine the e-commerce intensity in that county	ASM Survey
E-commerce Intensity by NAICS Code	E-commerce Sales divided by TVS for the three digit NAICS code	ASM Survey
Urban/Rural Dummy Variable	Simple measure of the urbanity of a county. Coded urban = 1 and rural = 0	USDA
Broadband Competition	Measures the total number of broadband providers in a county or in an economic area	FCC

Table 3.2: Additional Variables included in *Model 2*

Variable Name	Variable Definition	Source
County Level Education	The number of individuals that have an associates or technical degree in a county	Census Bureau
County Level Unemployment Ratio	Derived variable that measures the level of unemployment in a county, accounting for the workers in the establishment	ASM Survey and BEA
County Employment in Manufacturing	Number of people in a county that work in manufacturing	BEA
Number of Married Households	Number of married households in a county	Census Bureau
Establishment Labor Costs	Ratio of wages over value added for each establishment	ASM Survey
Minimum Wage	Minimum wage rate in a county	BLS
Population Density	The population density in a county	Census Bureau
County Total Wages	Total county wages	BEA
County Wage in Manufacturing	Total county wages in manufacturing	BEA
Labor Productivity	A monetary measure of the value of the total number of employees in an establishment divided by the total outputs of the establishment	ASM Survey

Dependent and Independent Variable Descriptions

Model 1: Characteristics Predicting E-commerce Intensity

In *Model 1*, predicting e-commerce intensity, the dependent variable is total e-commerce sales for each establishment. E-commerce sales is a continuous variable representing an establishment's gross sales made via e-commerce transactions. E-commerce sales are reported as a percentage of total sales for each establishment. As such, I constructed a continuous variable by using the total value of sales (TVS) and percentage of electronic sales for each establishment. Using the total value of e-commerce sales lets me to determine whether an establishment has reoriented its business practices to take advantage of e-commerce. *Model 1* includes ten independent variables; below, I describe those variables whose definitions are complex as well as those I developed by manipulating the raw data.

Establishment Outputs: Establishment outputs is a derived variable constructed by the Census Bureau the uses the following formula (TVS + (WIE-WIB) + (FIE-FIB))[8]. Establishments often ship their goods to other businesses, which then use them as raw inputs into the manufacturing process. The primary advantage of incorporating this variable is that it avoids duplicating the value of shipments whose contents are repurposed by another establishment in this manner. As such, it is the best measure available to compare the relative importance of manufacturing among industries and geographical areas. The establishment outputs serve as a proxy measure of the resources that are available to invest in new technologies.

[8] WIE (WIB) refers to work in process inventories end of year (beginning of year); FIE (FIB) refers to finished products inventories end of year (beginning of year)

Establishment Employment: Establishment employment is the sum of the number of production workers and non-production workers in an establishment.

Number of Non-Production Establishment Employees: Non-production establishment employees are those that are involved in factory supervision, sales, sales delivery, clerical and routine office functions, shipping, and record keeping among other non-production activities. This does not include proprietors or partners of the establishment.

Establishment Salaries and Wages: The gross earnings paid in a calendar year to employees.

Establishment Exports: Includes all exports going directly for export. It includes shipments of products to establishments and other customers that will export items. It excludes the value of products which will be further manufactured, fabricated, or assembled in this country before being shipped to foreign customers.

Establishment Outsourcing Costs: Outsourcing costs are the total payments made during the year for contract work done by others on materials furnished by the establishment.

E-commerce Intensity by County: E-commerce intensity by county is a constructed variable used to gage how intensely manufacturing establishments are engaging in e-commerce. The variable was constructed by collapsing TVS for every county establishment and collapsing e-commerce sales by establishment by county. E-commerce sales were then divided by county TVS to determine the e-commerce intensity in that county.

E-Commerce Intensity by NAICS: E-commerce intensity by NAICS is a constructed variable used to gage how intensely e-commerce is utilized in a particular manufacturing industry. The variable was constructed by collapsing TVS by the three digit NAICS code. E-commerce Sales were then collapsed by NAICS code as well. The E-commerce intensity by NAICS variable was constructed by dividing E-commerce Sales by TVS for the particular NAICS code.

Urban/Rural Dummy Variable: The Urban/Rural location variable is a dichotomous variable that provides a simplistic measure of the urbanity of a county, where urban = 1 and rural = 0. The Urban/Rural location variable was constructed using the Rural-Urban continuum codes produced by the United States Department of Agriculture (USDA). USDA codes counties on a scale from 1-9. Based on the definitions of these codes, I determine that counties that received a coding of 1-3 are considered urban and counties that received a coding of 4-9 are coded as rural.

Broadband Competition: Broadband competition is a variable that measures the total number of broadband providers in a county or an economic area. Using data from the Federal Communications Commission (FCC), zip codes that had three or fewer providers were coded as "0" whereas those areas with four or more providers were coded with the raw number provided by the FCC.

Model 2: Predicting E-commerce Intensity and the Effects on Labor Wages and Total Employment

The second, more complex model includes a number of additional factors that serve as instrumental variables. Data for the instrumental variables were collected from the Bureau of Economic Analysis (BEA), the Census Bureau, and the Bureau of Labor Statistics (BLS). The county-level data include several economic measures such as unemployment, employment in manufacturing, population density, wages, wages in manufacturing, and the minimum wage. Several county level population variables were also included such as county level education and the number of married households.

Model 2 incorporates three dependent variables: (1) establishment e-commerce sales, (2) establishment employment, and (3) establishment salaries and wages. These three dependent variables are measured the same way as in *Model 1*. These were selected as dependent variables due to the likelihood of a simultaneous relationship existing among them. For example, when a business initially adopts e-commerce practices, they do so for a variety of reasons; these may or may not be directly related to the size of its workforce or its wages structure. But once these systems have been put into place, I would anticipate that they would affect the total number of employees as well as wages. How might this play out? Conducting more transactions using e-commerce would likely reduce the number of an establishment's non-production workers. Yet there is a counteracting effect to consider – workers remain employed at an establishment would have to be technologically proficient so they could assist with e-commerce sales and coordinate supply chain systems. Given that these workers have more education and training, I would expect to see an increase in wages.

In addition to the independent variables included in *Model 1*, other variables were included in *Model 2* to serve as instrumental variables. The instrumental variables and how they were calculated are described below.

County Level Education: The number of individuals that have an associates or technical degree in a county.

County Level Unemployment Ratio: A calculated variable that measures the level of unemployment in a county. Calculated using the following equation:

$$\frac{\text{(County Employment - Establishment Employment)}}{\text{(County Workforce -Establishment Employment)}}$$

The unemployment ratio is included as an instrumental variable for Establishment Employment.

County Employment in Manufacturing: the number of people in a county that are employed in the manufacturing industry. This variable is included as an instrumental variable for Establishment Employment.

Number of Married Households: the number of married households in a county. This variable is included as an instrumental variable for Establishment Employment as previous research has demonstrated that married households can serve as a proxy for employment.

Establishment Labor Costs: unit labor cost is a constructed variable utilizing the following ratio:

$$\frac{\text{Establishment Salaries and Wages}}{\text{Establishment Outputs}}$$

This ratio is used to determine the average labor cost in an establishment.

Minimum Wage: minimum wage rates per state.

Population Density: the population density of a county. This variable is included as an instrumental variable for the Worker Wages.

County Total Wages: the total wages in a county.

County Wage in Manufacturing: the total wages in a county for those employed in manufacturing.

Labor Productivity: establishment employee value is a constructed variable utilizing the following ratio:

$$\frac{\text{Establishment Total Employment}}{\text{Establishment Outputs}}$$

This ratio is used to determine the average worker productivity in an establishment.

Methodology and Methodological Issues

The two models outlined above are used to generate insights into my primary research objectives; *Model 1*-- estimating which establishment characteristics predicted early e-commerce adoption among manufacturing businesses, and *Model 2* -- determining what effect e-commerce has on labor wages and total employment following its implementation. While these issues appear straightforward, their ostensible simplicity is deceptive because the predictive models necessary to provide a robust analysis are complex. To account for the various methodological issues, I opted for a Seemingly Unrelated Regression (SUR) model to explore the first research objective. The second research objective requires the use of a three-stage least squares (3SLS) estimation procedure. The following paragraphs discuss the various methodological issues negotiated throughout this dissertation and the rational for why the models ultimately chosen were the most appropriate.

The data used for this dissertation presents two primary methodological issues that had to be resolved to ensure the accuracy of analysis – autocorrelation and endogeneity. In traditional Ordinary Least Squares (OLS) estimation, the linear statistical model, written in matrix notation:

$$y = X\beta + \varepsilon$$

where OLS assumes that the error terms are uncorrelated random variables with a mean of zero and constant variance σ^2. However, this dissertation utilizes observations gathered over time and space—both instances that create the possibility of a violation of the OLS assumption of independence among the error terms. Given the likelihood that autocorrelation is present, the mathematical model must account for the correlated errors corresponding to different observations (Griffith 1993).

For both time-series and spatial autocorrelation, the equations' error terms are likely to be inter-correlated, which violates the independence assumption (Blalock 1971). Once the errors are not independent, parameter estimates are no longer BLUE (Best Linear Unbiased Estimator). When this occurs, statistical inference from the model may be unreliable for two reasons – 1) the estimated parameters are biased or inconsistent, or 2) the standard error of the parameter estimates are biased. More succinctly, stronger autocorrelation in the error term results in a greater loss of independent information during the estimation process, increasing the likelihood of inference errors (Voss et al. 2006). While the final methodological corrections to cope with these sources of autocorrelation are related, the following sections address them separately.

Spatial Autocorrelation

Spatial Autocorrelation is defined as a correlation among values of a single variable attributable to their relatively close locational positions (Griffith and Layne 1999), where spatial contiguity may result in a violation of the independence violation. There are several statistical tests available to determine if spatial autocorrelation is observable in a given model. The most common statistic used to detect spatial autocorrelation is Moran's I (Cliff and Ord 1981). But critically, Moran’s I can only *detect* spatial autocorrelation, it does not actually correct the methodological issue presented. If data are spatially autocorrelated, the strategy for resolving the issue depends on the model’s theoretical grounding and any peculiarities that are present. (Anselin 2002). Scholars have identified several ways to deal with spatial autocorrelation, including generalized least squares (GLS) and spatial autoregressive models (SAR) (Anselin 2002).

While I suspect spatial autocorrelation exists in both models based upon theoretical grounds, it was not possible to test for spatial autocorrelation using Moran’s I. However, my theory suggests that the locational setting in which an establishment performs it activities may influence its decision to adopt e-commerce. The locational setting may include the area of manufacturing that the establishment operates in, such as Transportation Equipment Manufacturing (NAICS 336) or Apparel Manufacturing (NAICS 315). However, the locational setting may also include informal interactions between an establishment’s decision makers, where these interactions are more likely to occur because they are co-located in a geographically proximate area. The reasons for these co-locations may occur due to factors implicit in urban and localization agglomerations. If, as my theory suggests, manufacturing establishments that adopt e-commerce tend to cluster spatially, the models will need to account for this. Ultimately, the models must correct for the theoretical presence of spatial autocorrelation, but must also provide a way to determine whether an establishment's locational setting plays a role in the establishment's adoption of e-commerce.

Because I suspect the presence of spatial autocorrelation exists, I need to take steps to specify a proper model that can account for it. Spatial effects must be explicitly incorporated into the specification of the model and estimated using a proper estimation technique (Voss et al. 2006). There are different ways to incorporate spatial effects into empirical models, including generalized least squares (GLS) and spatial autoregression (SAR). Standard GLS is one method to correct for spatial autocorrelation issues, as a GLS model captures the spatial relationships across the values of a dependent variable and shifts these values to the error structure. Although GLS yields a parameter estimate from which I could draw generalizations about the relationship between geographical spillovers and e-commerce adoption, I would prefer a tangible parameter estimate that will report the spillover, or contagion, effects statistically. Therefore, a more robust approach for my purposes is to rely upon a model that directly estimates the potential spatial effects.

SAR models provide an alternative for dealing with spatial autocorrelation in a more theoretically plausible manner. SAR modeling formally incorporates spatial effects directly into the empirical model. Spatial interaction is incorporated into the model specification, either through the use of a spatial lag or a spatial error. A spatial lag model incorporates a spatially lagged dependent variable on the right side of the regression model, whereas a spatial error model incorporates a correction for the autocorrelation either directly or by utilizing a spatial autoregressive process for the error term (Anselin 2002). Again, the type of model that is chosen to account for the spatial processes should match the underlying theoretical construct.

Based on its theoretical assumptions, a spatial lag model implicitly incorporates a spatial reaction function. Essentially, a spatial reaction function captures the interdependency of economic agents' behavior – it expresses to what extent the magnitude of a decision variable for one economic variable depends on the magnitude of the decision variable for other economic agents (Brueckner 2003). These models have been used to test various spillover effects at the county, city, and state levels (Kelejian and Robinson 1993; Murdoch et al. 1993; Case et al. 1993). Recently, spatial lag models have been used to test geographical spillover effects of economic externalities (Anselin 2003). Perhaps the most important component of the spatial lag model is the incorporation of the spatial weights matrix, as it is the spatial weights matrix that formalizes the network structure of the social networks for the economic agents in the dataset.

There are several ways that the spatial weights matrix can be defined, and there is very little formal guidance for choosing the "correct" spatial weights in any given application. Anselin (2002) suggests that choosing an appropriate spatial weights matrix should hinge on the spatial interactions patterns that are suggested for the analyst's theoretical framework. Traditionally a spatial weights matrix that is based on contiguity, which can take the form of a Rook, Bishop, or Queen lattice pattern or is generated through the use of geographical information systems.[9] Once the spatial weights matrix has been constructed, a model's spatial parameters can be estimated using maximum likelihood estimation.

A second method to account for spatial autocorrelation is through the use of a spatial error model. This type of model corrects for the 'nuisance' caused by spatial effects. The spatial error model can be interpreted as a way to 'clean' the dependent variable of the effects of spatial correlation, while maintaining consistent and efficient estimates (Anselin 2002). However, in the spatial error model, it is not possible to estimate the spatial parameter separately from the other parameters in the model.

[9] For an excellent review of these different types of patterns and some of the issues inherent to the creation of the spatial weights matrix, please see Grubesic (2007) and Anselin (2002).

Areal Units and Industrial Spillovers

The areal-unit issue I have to resolve relates to selecting the appropriate geographical level of analysis. In geography and regional studies, research on spillover effects are typically conducted at the levels of metropolitan statistical areas (MSA) (Koo 2005; Glaeser et al. 1992; Feldman and Audretsch 1999; Jaffe et al. 1993; Scott 1997), the Economic Area (Porter 2003), or the state (Audretsch and Feldman 1996; Feldman and Florida 1994).[10] Methodological and substantive difficulties arise when there is inconsistency in defining areal units to study geographically situated spillovers. Different statistical relationships can emerge when variables are aggregated at different levels of measurement. This is problematic because a naïve interpretation of data from different sources could lead to erroneous conclusions about the causal link between them. But there is no clearly defined or appropriate scale at which these spillovers may occur.

Glaeser et al. (1992) suggest that cities, as defined by the metropolitan statistical area (MSA), are an appropriate scale at which to measure the spatial extent of knowledge spillovers, as it is easier for intellectual breakthroughs to cross hallways and streets—rather than oceans and continents. Jaffe et al. (1993) use two different scales at which to measure the presence of knowledge spillovers, the state level and the MSA. Audretsch and Feldman (1996) use the state as the spatial unit of observation, although they suggest that more progress on the spatial dimension of innovation and knowledge spillovers could be made if there were data sources available that identified innovative activity at the city or county level. Feldman and Florida (1994) also use the state as the areal-unit at which to analyze the innovation process from a geographical perspective.

[10] My reference to spillovers may include knowledge or innovation spillovers that result from geographically proximate interactions between economic actors that are responsible for making decisions in an establishment.

Porter (2003) suggests that the economic area level is the appropriate geographical measure to assess innovation spillovers. Economic areas are smaller than states but typically larger than MSAs. Porter claims that economic areas are a better geographical measure than states or MSAs because they cover the entire U.S., have stable definitions over time, and are able to adequately reflect the true economic boundaries of regions because they can better capture patterns of market exchange. Aside from Porter (2003), no author has advocated for a specific areal-unit aggregate as the most appropriate for studying the geography of innovation and knowledge spillovers. However, there is significant agreement throughout the literature that geographical proximity has a critical influence over innovation and knowledge spillovers. But how to define and measure proximity is a topic of ongoing debate.

Time-Series Autocorrelation

The other form of autocorrelation I suspect is present in my data stems from the time-series component. Time-series autocorrelation has become a widely discussed modeling issue, and most scholars simply correct for bias in the standard errors created by multiple observations over time (Beck and Katz 1995, 1996). Although this methodological correction does not fix the bias that result from the multiple observations, it sufficiently corrects for the problem so that model results can be interpreted and inferences drawn. With respect to OLS, time-series autocorrelation tends to positively interrelate the error terms in adjacent time periods, thus violating the assumption of independence (Blalock 1971). Since the dataset contains multiple observations for each manufacturing establishment – one observation for each year – each establishment appears five times in the dataset (1999-2005).

Because the yearly observations for each manufacturing establishment are not independent of one another other, a violation of the independence assumption is likely to occur.

If a mathematical correction is not introduced, the model will treat each observation independently, creating biased standard errors. Although there are multiple methods and models to correct for time series autocorrelation, the best method, in this case, for correcting time series autocorrelation was through the use of Zellner's (1962) Seeming Unrelated Regression Model (SUR).

Endogeneity /Simultaneity

Another methodological problem this research confronts is the issue of endogeneity. Endogeneity can occur when the value of an explanatory variable is a consequence, rather than a cause, of the dependent variable. Therefore, the direction of the relationship between the two variables is ambiguous (King et al. 1994). If endogeneity is present, then the model's causal interferences will be biased – where the biased factor depends on the correlation between the explanatory variable and the error term. If, as in this case, potential endogeneity cannot be avoided, it can be corrected for after the fact (King et al. 1994).

In this dissertation, there are multiple endogenous variables and relationships, with additional endogenous variables nested within each of the models. As stated in the research design in Chapter 3, I directly hypothesize an endogenous relationship among: 1) e-commerce sales, 2) number of employees, and 3) employee wages. What this means is that an establishment may initially transition toward e-commerce activities because they have a large number of employees from which to draw the necessary IT expertise necessary to implement such an endeavor, while at the same time it may be seeking a strategy to reduce wages through the automation of certain job requirements. During the early phases of e-commerce adoption, companies saw e-commerce implementation as a competitive advantage strategy necessary for achieving efficiency gains (Porter, 2001). However, once an establishment adopts and implements e-commerce strategies, I hypothesize that there will be changes to the total number of employees and to the wages these employees are paid. In addition to the endogenous relationship between the three dependent variables, each model also incorporates several overlapping explanatory variables that further complicates the model and requires further consideration for those endogenous components as well.

To develop insights into the causal relationships between the dependent variables, I begin by reviewing the e-commerce literature to identify previous research that shed light onto these relationships. In the geography literatures, scholars have only infrequently engaged with problems of endogeneity or simultaneity. Endogeneity has not typically been addressed in studies that focus on e-commerce adoption in the social sciences. Studies that focus on an establishment's e-commerce adoption typically have relied on self-generated surveys and/or structured interviewing techniques to generate data points, i.e. research methods that allow authors to clarify the direction of causal relationships. Numerous studies have used survey techniques and/or interviews to determine why establishments adopt e-commerce activities (Daniel and Grimshaw 2002; Grandon and Person 2004; Riemenschneider and McKinney 2001; Mirchandani and Motwani 2001; Premkumar and Roberts 1999; Teo 2007). Because my work is based on a secondary data set I did not design, it is not possible to identify the causal links between different establishment characteristics through survey design or administration.

Researchers in other social science fields frequently use large secondary data sets when the casual links between variables are not immediately apparent; and not all these researchers use simultaneous equations to determine the causal direction between various relationships. Research by other scholars can assist in determining the directionality of causal relationships when a clear causal connection remains opaque. The literature on e-commerce does provide some insight into one of those relationships where the causal connection is unclear. Through the use of survey data, Daniel and Grimshaw (2002) assessed the relationship between an establishment's size and its motivations for adopting e-commerce; this study also evaluated the role of establishment size in e-commerce adoption rates. One of their survey questions asked about the motivation of adopting e-commerce, specifically whether adoption was attractive because it opened up opportunities to access global markets. According to their research, small and medium enterprises (SMEs) were more likely to incorporate e-commerce activities to expand their market reach than larger firms. In this case, the causal link between exports and e-commerce for SMEs is this: SMEs implement e-commerce to expand exports at a higher rate than do larger establishments.

Although Daniel and Grimshaw (2002) provide information on the casual links between e-commerce and exports, the relationships between the other expected endogenous variables (establishment outputs, wages, employment) are not directly addressed throughout the literature. As the literature lacks concrete guidance on these causal relationships, I will look at how endogeneity problems can be handled through modeling. One method for accounting for endogeneity through modeling is by using simultaneous equations. This is the method that my second model uses to correct for any bias they might contain. However, simultaneous equations do not imply causality, rather they simply correct for the bias it creates.

Methodological Solutions

The issues of spatial autocorrelation, areal and industrial effects, time-series autocorrelation, and endogeneity all introduce hurdles to modeling efforts. As the discussion above on spatial autocorrelation demonstrates, there are multiple methods scholars have used to adjust statistical models for the presence of spatial autocorrelation. For this analysis, the best theoretical fit to account for the presence of spatial autocorrelation is the spatial lag model with a spatial weights matrix designed to test the spillover effects of e-commerce adoption. However, given the constraints of the statistical software packages available at the Center for Economic Studies, it was not possible to create a spatial lag model. Instead, I constructed an independent variable from Census data that directly measures the level of e-commerce intensity at the levels of the 1) county and 2) economic area. Directly measuring the level of e-commerce intensity in a delineated area establishes a direct measure of the e-commerce spillover effects within that spatial frame. Theoretically, it is more likely that if manufacturing establishments adopt and implement e-commerce activities because other manufacturing establishments have adopted e-commerce, then those establishments co-located within the same county or economic area are more likely to influence adoption. Even if a spatial lag modeling method had been available, it would have merely adjusted estimates based on e-commerce adoption in establishments located in the county or economic area next to the county or economic area where the establishment of interest is located. Measuring the effects of inter-county or inter-economic area e-commerce is a better measure of the spatial cascade effect for the purposes of this analysis.

The literature was also unclear as to the appropriate geographical areal unit to analyze spatial spillovers. As there is no clearly pre-defined scale at which locational spillovers are thought to occur, I selected the two most theoretically appropriate scales to measure the spatial extent of the spillover.[11] The first scale I selected is a county level measure of the hypothesized

[11] There may be evidence of these spillovers at the zip code level because of the increased chance that an economic actor has in interacting with other economic actors at this relatively smaller geographical area. However, previous research has demonstrated that there are issues with aggregating data at the zip code level. Essentially, this can be problematic because as a geographically bounded area, zip codes are not t regulated by any specific distance measure, population threshold, or political boundary (Grubesic 2007). So there are cases where a single zip code could cover a large geographical area with a sparse population or it could cover a relatively small geographical area with thousands of people. There is also the change that measuring the locational spillover effects at the zip code level is too small of an areal aggregate to adequately measure the extent to which knowledge and innovations may flow. Certainly there are many zip codes within a given urban area, so limiting my analysis to this lower level may not give an accurate picture of the locational spillover.

spillover effects. Measuring spillovers at the county level confers several pragmatic advantages. First, in some cases, measures at the generally smaller county level are more geographically proximate than measures at the larger MSA level. As I have hypothesized, geographical proximity should directly affect whether an establishment adopts e-commerce activities due to what is observed and occurring in other nearby establishments. For example, imagine that a small number of firms decide to implement e-commerce activities. As they begin to realize positive returns on investment, it may drive other local firms (competitors or otherwise) to likewise adopt e-commerce; thus, adoption leads to diffusion of e-commerce implementation at local or regional levels. Aggregating establishment to the county level also has the added advantage of linking the establishment level data from the ASM to a variety of other measures of interest to this analysis. These include measures from the Bureau of Labor Statistics (BLS), the Bureau of Economic Analysis (BEA), the Census Bureau, the FCC, and the USDA. Please refer back to Table 3.2 for a full listing of variables coded at the county level.

Although analysis at the county level is an appropriate areal-unit measure for this project, it is possible that measuring knowledge spillovers at the county level may conceal the full impacts of localized diffusion of e-commerce adoption. One reason for this is that urban areas tend to encompass larger geographical areas than just a single county. Therefore, counties may not adequately capture how widely – or narrowly – a particular establishment's effects may spread. To unpack the extent to which diffusion may occur within an economic area, I will aggregate data to the economic area level, which was specifically designed to capture the true economic boundaries of an area.

To construct a county level measure of e-commerce intensity, the total value of sales (TVS) for each establishment within a county was aggregated into a single measure. The same process was repeated for each establishment's e-commerce sales. The aggregate of county level e-commerce sales was divided by the aggregate of county level TVS. E-commerce intensity in an economic area was calculated using the same method as was used for the county level measure. The only notable differences were that TVS and e-commerce sales were aggregated to the economic area level, as defined by the BEA, as opposed to the county level.

Another question this dissertation addresses is whether or not the effects of e-commerce observed within an establishment are specific to that establishment or if they are more systematic to the establishment's industry. According to the Census Bureau, from 1999 to 2005, approximately 70 percent of the manufacturing sector's value of e-shipments was concentrated in six manufacturing industry groups (U.S. Census Bureau 2007). These statistics suggest that industry membership likely influences whether an establishment uses e-commerce. To account for the industry influence on whether or not an establishment adopts e-commerce, I develop an independent variable to account for these spillover effects. This variable represents the level of e-commerce use among all the *other* establishments within the industry context, measured as the value of electronic sales among all the other establishments divided by total sales among those establishments. The industry context to compute this measure will use the individual NAIC codes at the three digit level to set up a proportion for each establishment in the dataset. For example, the equation for an establishment "a" in industry "x":

$$\frac{ECVS_b + ECVS_c + \ldots ECVS_z}{TVS_b + TVS_c + \ldots TVS_z}$$

Where ECVS=E-commerce Value of Shipment by industry x and TVS=Total value of shipments by industry x.

The methodological issues pertaining to spatial autocorrelation, selection of the appropriate areal unit, and systematic industrial effects, are resolved through the development of variables; the construction of these variables is justified in light of the existing literature. However, the issues of time-series autocorrelation and endogeneity can only be sorted through equation modeling. In *Model 1*, I use a Seemingly Unrelated Regression Model (SUR) to explore establishment characteristics that predict e-commerce adoption (Zellner 1962). A SUR model is appropriate as I have multiple years of data and the SUR model will account for the stochastic dependence that is a product of having multiple observations spread across time.

I chose the SUR model to ensure that the contemporaneous correlation between error terms would be accounted for. By estimating all equations simultaneously, I make the same assumption used when estimating an OLS model. However, again, the major difference between the two models is the assumption of contemporaneous correlation across the disturbance terms.

$$\text{cov}\,(e_{1,t}\, e_{2,s}) = \sigma^2_{1,2}$$

Separately, the SUR equations are written as

$$Y_1 = X_1\beta_1 + e_1$$

$$Y_2 = X_2\beta_2 + e_2$$

$$Y_3 = X_3\beta_3 + e_3$$

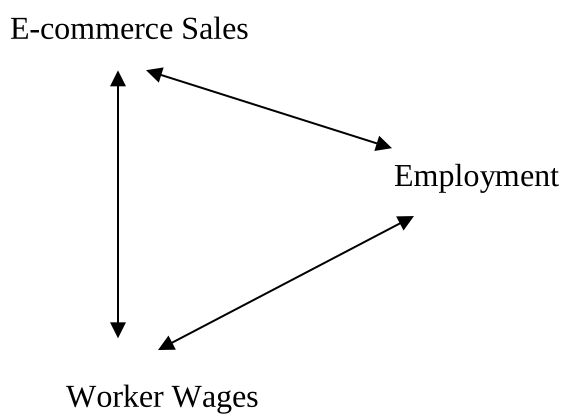
$$Y_4 = X_4\beta_4 + e_4$$

$$Y_5 = X_5\beta_5 + e_5$$

Where Y_1 is the element column vector of e-commerce observations for each establishment in year 1 (i.e. 1999). Other years included are Y_2 = 2002, Y_3 = 2003, Y_4 = 2004, and Y_5 = 2005. The combined system of equations can be written as $Y = X\beta + e$, which is very similar to OLS, but again, estimating using OLS would be inefficient due to the mis-specification of the error term.

Model 2 investigates hypotheses related to the question of how e-commerce is adopted and the effects of adoption on labor and wages at manufacturing establishments. The most parsimonious option to account for the model's theorized endogenous component is to estimate the model using 3SLS estimation for a system of structural equations.[12] To reiterate, the three dependent variables I hypothesize to have a direct causal relationship are: 1) the number of employees in an establishment, 2) employee wages, and 3) e-commerce intensity. Figure 3.2 visualizes the expected relationship between these three variables.

Figure 3.2: Hypothesized endogenous relationship between E-commerce Sales, Employment, and Worker Wages



[12] Stata's *reg3* command estimates the system of equations via three-stage least squares. However, Stata's *reg3* command assumes that the only endogenous variables in the system of equations are the dependent variables. In this case, there were several additional explanatory endogenous variables that were necessary to define. By defining the additional variables that were endogenous to the system through the *endog* command, Stata accounted for the error terms among the equations that are expected to be correlated. Therefore, the *reg3* command, combined with the *endog* option, allowed for the inclusion of the endogenous dependent variables, several endogenous explanatory variables, and a variety of exogenous explanatory variables.

As hypothesized in chapter 2, the model above suggests that there is a direct relationship between the type and number of workers employed in an establishment directly influences whether or not the establishment adopts e-commerce. However, I also hypothesized that as establishments adopt e-commerce, they will recalibrate the number of non-production workers employed, leading to a smaller number of non-production workers being employed. Another complicating factor in the relationship between e-commerce sales and employment is that worker wages also influence e-commerce sales and employment. That is, as the number of employees' declines at an establishment, the remaining workforce's obligations and level of technological expertise will both increase because e-commerce activities demand that workers have a new set of technological proficiencies. As such, workers with technologically sophisticated skill sets would be expected to earn higher wages.

To estimate the 3SLS model, I selected a group of instrumental variables for each dependent variable. Figure 3.3 graphically maps the underlying logic of the simultaneous equations model, including the three dependent variables (e-commerce sales, establishment employment and establishment worker wages), the four additional endogenous variables, and the instrumental variables. The 3SLS system of equations can be written as:

$$y_1 = \hat{y}_1\beta_1 + X_1\gamma_1 + u_1$$

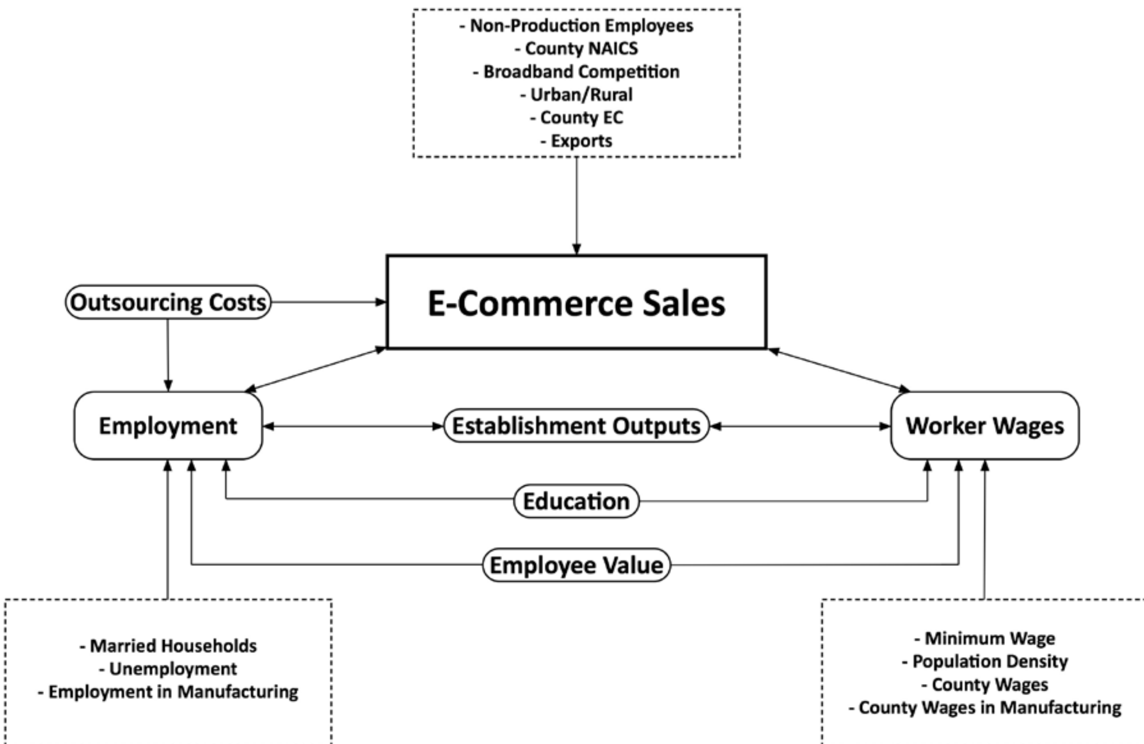
$$y_2 = \hat{y}_2\beta_2 + X_2\gamma_2 + u_2$$

…

$$y_G = \hat{y}_G\beta_G + X_G\gamma_G + u_G$$

Where y1 is a vector of the endogenous variable and $\hat{y}_1$ is a matrix of the remaining endogenous variables in the first equation. X_1 is a matrix of the predetermined variables in the first equation and u_1 is a vector of the disturbances in the equation (Kmenta 1997).

Figure 3.3: Variables and their directional relationship in Model 2



Methodological Weaknesses:

My approach has several potential weaknesses. First, economists have suggested that the full effects of the IT revolution on productivity have yet to be seen in terms of productivity because, like other general purpose technologies, it may take years before we can confidently measure the effects of IT on productivity (David 1990). Therefore, for the study period under analysis, it may be too early for the effects to have fully materialized. That is, it may be too early to tell if fewer employees in the establishments that adopt e-commerce, can be directly attributed to e-commerce.

A second weakness with my approach concerns the forward and backward linkages of e-commerce. Unfortunately, the data I use only permits the evaluation of forward linkages in e-commerce. Although the Census bureau defines e-commerce as "any transaction completed over a computer-mediated network that transfers ownership of, or rights to use, goods or services" the way an establishment's use of e-commerce is measured is based on the percentage of the total value of products shipped whose movement was controlled over electronic networks. Essentially, my data only covers the percentage value of sales that are conducted over electronic networks. I do not have any type of information about backward linkages. For example, my data do not reflect the extent to which an establishment purchases supplies over electronic networks. As such, my measure of e-commerce usage in an establishment may be too conservative, and it may underestimate the full impacts of e-commerce in the production process. While this is problematic, having a more conservative estimate may not necessarily be a drawback in terms of this analysis. If there is evidence that a higher level of e-commerce usage is associated with fewer employees, then a less conservative estimate of e-commerce should only reinforce this finding.

4. Electronic Commerce Adoption, Integration and Firm: Predicting Firm Characteristics of Early E-Commerce Adopters

This chapter examines the characteristics of U.S. manufacturing establishments that were early adopters of e-commerce. Using the data described in chapter 3, a seemingly unrelated regression (SUR) model is employed to determine 1) which characteristics were important predictors of e-commerce adoption and integration, 2) which hypotheses were or were not supported empirically, and 3) whether these results differentiated between the two scales employed for this analysis.

Proponents of electronic commerce initially held out some hope that e-commerce adoption could radically alter economic relations geographically. E-commerce could allow relatively isolated establishments the chance to process and fill purchasing orders from a dispersed clientele, and could allow those clients a convenient means of supplying their operation from a geographically dispersed network rather than merely from convenient local suppliers. Partly because it would lessen the importance of the physical location to an establishment's sales, but only partly as a result of that, e-commerce also seemed to promise (or threaten) radical alterations in existing economic relations. Smaller establishments in economically distressed regions would be able to outperform, due to their lower wages and operating costs, bigger establishments whose strength depended on the convenience of being in the right place and of which they could pass the burden of their operating expenses onto the nearby clients. Employment and wages might rise in establishments adopting e-commerce, relative to those that did not.

Nothing guaranteed that e-commerce would bring about radical economic changes, however. Establishments needed to adopt e-commerce in a way that cut against previous patterns of economic and geographic dominance, and their clients needed to alter their purchasing behavior in such a way that sales activity would detach itself from the traditional constraints employed through the use of older technologies. Yet both e-commerce adoption and integration were not going to occur randomly or in a vacuum. The process would be shaped by systematic forces that could reinforce or even strengthen the influence of place and of existing capital. Adopting e-commerce might depend on available labor, available technology, available funds for investment, and whether an establishment already had reached sufficient scale of operations to warrant branching off with a novel technique. A firm's ability to market goods through e-commerce and supply goods in large scale to a clientele accessed through e-commerce similarly might depend upon labor, technology, capital, scale, and access to convenient transportation networks. Nor would e-commerce necessarily improve the employment and wages in an establishment. By easing the process of selling to far-flung customer networks, e-commerce could reduce demand for mid-level marketers, sales executives, logistics experts, and so on, resulting in an establishment structure in which everyone except for a few well-paid executives and technicians tended to be low-paid workers on the faculty floor or in the warehouse (albeit perhaps better paid than they were when they needed to operate under a bigger layer of mid-level clerks and the like). Far from liberating economic exchange from its old patterns, e-commerce might make them even more ingrained – if not worsen them.

Ultimately, these are empirical questions – as regards what e-commerce has done so far, if not what it remains to do – and the remainder of this thesis will try to answer those empirical questions. This chapter tackles the first question: What systematic characteristics shaped the adoption and integration of e-commerce? The next chapter looks at the second process: Which systematic characteristics helped determine the volume of sales through e-commerce? Projecting from observed patterns to likely future patterns requires extrapolating beyond the bounds of my data, always a risky endeavor, but it lessens the amount of speculation needed when compared to a purely theoretical treatment of e-commerce.

The models employed in these two chapters differ, and I do not pretend that this two-step approach represents the most optimal or most methodologically sophisticated way to analyze questions asked by this thesis. The Census Bureau protects the privacy of establishments that answer their survey, which means that I needed to go into their Chicago-based data center alone with few resources, run the models that I had already planned with limited time for trying alternative specifications, and take from there little more by way of statistics than the model estimates I had produced. The research design therefore needed to restrict itself to models that the statistical software package Stata already had been programmed to run, and models that I possessed sufficient training to evaluate and interpret, not optimized models that I might program on my own remotely or on the spot. In particular, these constraints meant that I needed to address methodological complications separately – hoping that different models with different known limitations would protect me from inferential errors – rather than trying to set up some master model that tackled all of the methodological complications at once.

Two methodological complications in particular demanded attention when predicting e-commerce sales. First, my data looked at establishments over multiple years, in panel form – not in a clean time series, with the spacing between years uniform, but in a staggered pattern. The analysis needed to take into account that the behavior of an establishment in one year likely correlated with its behavior in other years, and not by assuming some smooth pattern across time, because both the dot-com bust and changes in survey methodology interfere with the series.[13] Second, the errors I might have produced when predicting an establishment's e-

[13] The 2000 CNUS was provided to the wrong manufacturing administrators, resulting in unreliable survey estimates for that year. The 2001 microdata was not released for analysis. Repeated requests to the Census Bureau by both myself and the Chicago RDC administrator for an explanation were ignored.

commerce activity might be shaping employment and wages in a given year, rather than only depending on them, which could create simultaneity bias. It was not feasible to adjust my model for the autocorrelation over time – let alone use a novel panel-data model to do so – at the same time I set up simultaneous equations to get at the endogeneity among my three outcomes.

Instead, the model reported in this chapter will address the time-series problem. It uses a seemingly-unrelated regression (SUR) framework so that the estimates can be sensitive to how prediction errors for an establishment in one year might be correlated with those in other years (not just the year before, as a simple AR1 time-series model might have done). This approach does not create a straight-up time-series model, such that I am trying to create a single estimate of what was happening over the time period; it will produce a model describing the pattern for each year of data I've got. However, the three-stage least squares model, presented in chapter 5, makes up for that inefficiency by taking into account patterns among the residuals. Although the model in the next chapter will address the simultaneity problem, it does so without throwing the wide net to catch all of the potential patterns in the residuals.

Researchers typically tie a wide variety of variations to their models before finally settling on the ones to present, an approach that sacrifices scientific credibility because it risks overfitting the model and because testing a model using the same data from which one develops the model creates confirmation bias. Whatever temptation I might have faced to indulge in this modelling flexibility was suppressed by my limited access to the data. However, I did plan in advance one variation in my approach – a variation that applies to the models in both chapters. Specifically, I wanted to determine whether my results would be robust to the choice of areal unit in which I embedded my spillover-effects variable. Overall, this results in four estimations. This chapter therefore will present the analysis once using counties as the areal unit in which spillover effects could be taking place, and a second time using economic areas as that areal unit.

The following chapter will split the model into two versions as well. This two-pronged approach does not simply serve to confirm one areal effect by looking at another. It tests for the possibility that the areal effect is embedded in one sort of areal unit more so than in the other.

Predicting E-Commerce Adoption: The County Effect

Seven of my nine hypotheses specifically applied to the e-commerce adoption dependent variable. By way of review, those hypotheses were:

Hypothesis 1: Large U.S. manufacturing establishments will have higher rates of e-commerce adoption.

Hypothesis 2: Exports will be higher among U.S. manufacturing establishments that use e-commerce.

Hypothesis 3: E-commerce adoption will be higher among establishments that outsource parts of the manufacturing process to contract workers.

Hypothesis 4: E-commerce adoption will be higher among U.S. manufacturing establishments that have higher wage rates for workers.

Hypothesis 5: E-commerce adoption will be higher in urban areas than rural areas.

Hypothesis 6: E-commerce adoption will be higher among establishments that are co-located near other establishments using e-commerce.

Hypothesis 7: E-commerce adoption will be higher among establishments in industrial sectors where e-commerce adoption is also high.

Model 1 offers the first test of each of these ideas, and I will spend most of my analysis developing that model. Later models of e-commerce intensity will only outline changes from the results explicated here. Table 4.1 presents the seemingly unrelated regression results using establishment level and county level variables.

Table 4.1: Characteristics Predicting E-Commerce Intensity in Manufacturing Establishments--County Level Measure

Seemingly Unrelated Regression	E-Commerce 1999		E-Commerce 2002		E-Commerce 2003		E-Commerce 2004		E-Commerce 2005	
Total Employment	14.2357	***	-242.0809	***	-222.9438	***	-265.0428	***	-308.7541	***
	(4.302)		*(5.524)*		*(5.688)*		*(5.927)*		*(7.714)*	
Establishment Outputs	0.1000	***	0.5424	***	0.6119	***	0.5439	***	0.4049	***
	(0.007)		*(0.045)*		*(0.007)*		*(0.006)*		*(0.006)*	
Wages	0.9722	***	6.8222	***	7.1304	***	8.5266	***	10.0878	***
	(0.084)		*(0.064)*		*(0.100)*		*(0.097)*		*(0.133)*	
Exports	0.5356	***	0.5187	***	0.2990	***	0.3318	***	0.3863	***
	(0.020)		*(0.024)*		*(0.022)*		*(0.020)*		*(0.027)*	
Non-Production Employment	-90.5968	***	-256.7816	***	-333.0237	***	-357.2592	***	-388.3830	***
	(5.560)		*(7.150)*		*(8.238)*		*(8.435)*		*(11.709)*	
Outsourcing	-0.3192	***	-0.8137	***	-0.8485	***	-0.3713	***	-0.0161	
	(5.560)		*(0.098)*		*(0.099)*		*(0.087)*		*(0.118)*	
E-Commerce Intensity (County)	127200.0000	***	130950.7000	***	118463.5000	***	114989.6000	***	137233.1000	***
	(5208.528)		*(6169.929)*		*(5179.987)*		*(4809.326)*		*(6496.384)*	
E-Commerce Intensity (NAICS)	62446.0900	***	106030.4000	***	103667.1000	***	97324.0900	***	109882.6000	***
	(15080.050)		*(11445.020)*		*(11767.820)*		*(12179.220)*		*(16851.980)*	
Urban/Rural Location	1845.0090		-3493.3030		-4821.3970		-5283.7810		-7615.6640	
	(1761.832)		*(2570.979)*		*(2965.078)*		*(3197.860)*		*(4095.858)*	
Broadband Competition	-0.2906		-0.9180		-1.8464		-2.4209		-2.1007	
	(3.722)		*(5208.528)*		*(2.501)*		*(2.455)*		*(2.994)*	
Observations	17769		17769		17769		17769		17769	
R^2	0.2353		0.4923		0.5419		0.5021		0.4268	

The claim that large establishments were early e-commerce adopters is a well-defended proposition, but this model puts two measures of establishment size up against each other: employment and outputs. *Model 1* suggests that the driving force behind e-commerce adoption is an establishment's financial size, the total amount of their outputs. Establishments with high-volume sales were most likely to branch out into e-commerce. Initially, in 1999, employment size also had an independent and positive effect on e-commerce intensity, but within just a few years, the coefficient on employment turns strongly and significantly negative. This does not mean that establishments with fewer employees have more e-commerce intensity, because it's a result that only appears after I control for outputs. What this negative effect means is that a firm with relatively few employees, given its total output, if anything will have more e-commerce intensity than a heavily staffed firm. That output matters so much, and that employment cuts in the wrong theoretical direction, opens up the possibility that over time e-commerce might undercut employment numbers (especially among non-production personnel) while increasing wages for the employees who remain – a topic I take up in the next chapter. For now, it suffices to observe that I have confirmed **Hypothesis 1**: Larger establishments were indeed more likely to transition into e-commerce sales.

Does e-commerce intensity correlate with an export-focused orientation among establishments, as posited by **Hypothesis 2**? Table 4.1 suggests that it does, although the effect diminishes over time. Initially, export-oriented companies were especially inclined to adopt e-commerce, but by 2003 domestically oriented establishments were catching up, weakening the strength of that distinction.

The prediction with regard to outsourcing part of the labor process to contract workers, **Hypothesis 3**, does not hold up in this initial model, nor will it hold up in any model to come in this thesis. Establishments that outsource more labor to contract workers do not appear to have engaged in e-commerce adoption at a higher rate than other establishments. If anything, they are less likely to have gotten into the e-commerce side of things. This unexpected pattern is statistically significant in most of my models, so it is good that those models are controlling for the pattern when constructing estimates for more-important independent variables that I am using, but it does leave a puzzle that future research could try to explore. One possibility is that when establishments outsource work, they are generally outsourcing parts of the production process—not the non-production side, which is usually the target of e-commerce activities.

Hypothesis 4 fares better in *Model 1*. Establishments that pay higher wages, controlling for their volume of sales as well as their quantity and type of employment, were more likely to engage in e-commerce activity from the beginning of my time period – and that tendency only strengthens with time. However, this result (as with the one on quantity of employees) may reflect bias created by endogeneity. Having well-paid employees may not have made it easier for establishments to jump into e-commerce. Rather, the efficiencies of e-commerce activity may have generated revenues that employers could convert into more-generous pay scales. Pinning down the directional relationship between wages and e-comment intensity awaits confirmation in the next chapter.

My blunt measure for whether an establishment operates in an urban area does not much help predict e-commerce intensity. The idea that rural establishments might be able to overcome their previous locational disadvantage by engaging in e-commerce is not rebutted: After a relatively slow start in 1999, rural establishments by 2002 do see greater e-commerce activity than urban establishments, and it increases over the time period. Thus, there is support for **Hypothesis 5**. However, the variation within rural and urban areas is high while the variation between the two sorts of areas is modest. Not even the biggest estimated difference between the two locales, the one observed in 2005, manages to achieve statistical significance. I cannot say with confidence that rural areas stand out. The amount of broadband competition in the county, meanwhile, does no better. The coefficient for that variable is not statistically significant, and even goes in the wrong direction, a direction for which I have no theoretical explanation. Best guess: Neither of these variables makes much difference, once the other explanations have been taken into account.

The last two hypotheses consider the role of contextual effects on e-commerce intensity: the geographic context and the industrial context. Other things being equal, an establishment should be more likely to adopt and achieve success with e-commerce if the other establishments in the area and/or in the industry use e-commerce as well. In fact, both of the hypothesized contextual effects appear in every year of data available to me. (Remember: These explanatory variables have factored out the establishment's own e-commerce activity, so the independent variables truly are independent with respect to the dependent variable.) The model in Table 4.1 shows that establishments in counties otherwise rich in e-commerce are themselves likely to have greater e-commerce intensity than are establishments in county where such activity tends to be rare. The effect stays relatively constant throughout the time period, bouncing around from year to year about as much as would be expected given the coefficient standard error. Thus, **Hypothesis 6** is confirmed. Meanwhile, industries do appear to move together into e-commerce: Establishments in industries using e-commerce heavily are themselves significantly more likely to report high e-commerce intensity. The effect starts relatively small in the earliest year, when e-commerce adoption was spottier, but the effect almost doubles after the dot-com bust and stays consistent afterward. So the county commonalities are not the result of industry commonalities, and vice versa. Hence, Hypothesis 7 is also confirmed. Essentially, both contextual effects independently help predict e-commerce intensity.

The spotty nature of e-commerce activity in 1999 compared to the later years also shows up when evaluating the fit of this Seemingly Unrelated Regression Model. The fit of the model in 1999 is not terribly impressive: The R^2 of .24 indicates that the vast majority of the variation in e-commerce intensity from one establishment to another cannot be explained by my model. The same model doubles in predictive power by 2002, when e-commerce activity had become more standardized (the R^2 starts at .49 and varies between .43 and .54). Given the wide variety of e-commerce intensity seen in these 17,769 establishments and the parsimony of the model, being able to explain roughly half the variance is a good sign.

Predicting E-Commerce Adoption: The Economic Area Effect

Table 4.2 reports a model very similar to the one in Table 4.1, except it alters one crucial implementation decision: Instead of embedding an establishment within the county for purposes of determining contextual traits, it embeds establishments in a geographically defined economic area. The model also makes one other change because it’s no longer set in the county: The Urban/Rural variable no longer applies when I move beyond the county context, so it is removed.

Table 4.2: Characteristics Predicting E-Commerce Intensity in Manufacturing Establishments--Economic Area (EA) Measure

Seemingly Unrelated Regression	E-Commerce 1999		E-Commerce 2002		E-Commerce 2003		E-Commerce 2004		E-Commerce 2005	
Total Employment	13.4012	**	-244.3732	***	-225.7196	***	-266.9564	***	-309.9102	***
	(4.314)		*(5.526)*		*(5.681)*		*(5.926)*		*(7.714)*	
Establishment Outputs	0.0993	***	0.5458	***	0.6140	***	0.5465	***	0.4073	***
	(0.007)		*(0.008)*		*(0.007)*		*(0.006)*		*(0.006)*	
Wages	1.0040	***	6.9114	***	7.2206	***	8.5981	***	10.1535	***
	(0.085)		*(0.110)*		*(0.101)*		*(0.098)*		*(0.133)*	
Exports	0.5444	***	0.5264	***	0.3030	***	0.9963	***	0.3909	***
	(0.020)		*(0.024)*		*(0.022)*		*(0.020)*		*(0.027)*	
Non-Production Employment	-91.6850	***	-261.0817	***	-336.1756	***	-360.8551	***	-393.2304	***
	(5.619)		*(7.197)*		*(8.267)*		*(8.468)*		*(11.761)*	
Outsourcing	0.3365	***	-0.8299	***	-0.8644	***	-0.3815	***	-0.0204	
	(0.073)		*(0.099)*		*(0.100)*		*(0.088)*		*(0.118)*	
E-Commerce Intensity (EA)	103190.3000	***	94877.1400	***	87199.1100	***	86329.5100	***	109475.3000	***
	(9599.299)		*(9267.069)*		*(7864.136)*		*(7875.783)*		*(10481.330)*	
E-Commerce Intensity (NAICS)	81276.8500	***	112850.7000	***	111621.1000	***	103621.3000	***	118217.9000	***
	(15275.940)		*(11520.050)*		*(11809.460)*		*(12229.440)*		*(16918.360)*	
Broadband Competition	0.0001		0.0000		0.0001		-0.0006		-0.0010	
	(0.002)		*(0.000)*		*(0.001)*		*(0.001)*		*(0.001)*	
Observations	17769		17769		17769		17769		17769	
R^2	0.2149		0.4867		0.5374		0.4977		0.4221	

These measurement changes alter very little about the results reported with the last model. The control variables – wages, exports, non-production employment, broadband competition – all behave as before. The counterintuitive relationship between outsourcing and e-commerce intensity also remains.

One major question for this research was whether establishment size works to increase e-commerce intensity. The related hypotheses work roughly as they did in Table 4.1. Establishment output still starts weak in 1999 but strengthens in the later years, so establishment size does coincide with greater e-commerce intensity. Size as measured by employment, however, does not show this positive effect with e-commerce. Controlling for outputs, firms with higher levels of employment have lower levels of e-commerce in this model as well – which could be genuine, or could be a product of endogeneity that the model in the next chapter can estimate.

The only consequential difference in this model from the last is the relative performance of economic areas compared to counties. E-commerce intensity in the economic area does not predict an establishment's activity as well as it did when testing the variable at the county level. The differences between these two areal scales are that the economic area is comprised of multiple counties that are composed of the relevant regional markets surrounding metropolitan areas (Johnson and Kort 2004). Therefore, the knowledge spillover effects for establishments engaging in e-commerce are more pronounced for those establishments that are geographically more proximate to other establishment's engaging in e-commerce. The fit of the economic area model falls short of the county model's performance as well, with the R^2 of the model in Table 2 smaller in all five years.

Model 1 Outcomes

E-commerce seemed to promise an opportunity to overturn established patterns of economic activity, especially as regards geography. On one hand, smaller establishments could take advantage of the way e-commerce allowed them to take orders and deliver product efficiently. Rural firms, once disadvantaged by location, might be able to turn their isolation into an advantage once electronic resources enabled them to engage with more spatially distant clients. On the other hand, the ability to adopt e-commerce and succeed at it likely depended on having the size, volume of sales, high-paid work force, and overall context needed to facilitate such an innovation.

The results of this chapter support the latter idea. Far from overturning past patterns, e-commerce adoption appears to have responded to and reinforced them. Establishments that already enjoyed greater output, higher wages, an export orientation, and a workforce tilted toward higher employment adopted e-commerce and saw higher levels of e-commerce intensity from 1999 through 2005. Rural areas did not show any impressive tendency to jump on the e-commerce bandwagon and overcome their isolation with sales delivered electronically. Establishments operating within a context rich with e-commerce activity, both in terms of their geographical location and in terms of their industry, tended to see e-commerce take root. The revolutionary potential of e-commerce did not appear to play out in these establishments.

5. Electronic Commerce Intensity, Labor Wages, and Establishment Employment in the Manufacturing Industry

The last chapter focused on e-commerce adoption and integration. The patterns of establishment activity observed in the two models found signs that e-commerce reinforced some of the existing inequalities in the manufacturing sector, rather than undermining them. However, the models reported in chapter 4 offered only limited treatment of employment and wages, though.

One shortcoming of the models in the last chapter is that they provided unreliable coefficients for the wage variable and the total employment variable. The models assumed that employment and wages determine e-commerce intensity and do not depend on it. An endogenous relationship among those variables would violate the model assumptions implicit in a seemingly unrelated regression (SUR) analysis. And those assumptions make little sense, given that selling goods through electronic means likely would result in different employment demands and eventually reflect a different sort of workforce, one that might differ in both size and wages paid.

More important, the revolutionary potential of e-commerce was not only supposed to be about the adoption stage – which, by focusing on e-commerce intensity, was the last chapter's main focus. E-commerce intensity matters in part because of how it might change the employment and wage prospects of the workers who staff establishments using the technology. The three-stage least squares (3SLS) model presented in this chapter not only offers a second pass at the models from the last chapter – foregoing the estimation advantages of a SUR model in exchange for one that could tackle possible endogeneity in the variables – but the new simultaneous-equation model also includes sub-models using employment and wages as outcomes of interest.

Predicting E-Commerce Intensity

Table 5.1 shows the part of the new model that still tries to predict e-commerce intensity. Although trying to account for endogeneity between that intensity and wages/employment does destabilize the model somewhat. For example, the R^2 for all five years diminishes as a result of this modelling change. This loss of model fit makes sense if some of the predictive power in the model estimated using the seemingly unrelated regression method (Table 4.1 in the previous chapter) in that it actually represented influences running from dependent variable to the independent variables, contrary to the model assumptions. In the new model, the instrumentation provided by 3SLS stripped out some of that common variation between the independent variables and the dependent variables, leaving only the relationship that appears to go from wages/employment to e-commerce rather than the other way around. The loss in model fit is strongest in the early years, whereas the models look more alike starting in 2003.

Table 5.1: Three Stage Least Squares with Dependent Variable E-commerce

Areal Unit of Measure: County Level	E-Commerce 1999	E-Commerce 2002	E-Commerce 2003	E-Commerce 2004	E-Commerce 2005
Total Employment	167.1658 ***	-645.9089 ***	-20.7040	-372.3619 ***	-717.0774 ***
	(16.601)	*(24.806)*	*(27.092)*	*(23.780)*	*(29.550)*
Establishment Outputs	0.3817 ***	0.1429 **	0.6056 ***	0.4009 ***	0.3625 ***
	(0.032)	*(0.045)*	*(0.054)*	*(0.046)*	*(0.041)*
Wages	-2.4182 ***	13.8047 ***	0.9992 **	10.8447 ***	16.6712 ***
	(0.338)	*(0.391)*	*(0.407)*	*(0.332)*	*(0.454)*
Exports	0.4157 ***	0.7300 ***	0.7104 ***	0.3129 ***	0.2068 ***
	(0.037)	*(0.046)*	*(0.046)*	*(0.036)*	*(0.049)*
Non-Production Employment	-97.1307 ***	-164.7854 ***	-72.8536 **	-329.5174 ***	-350.1296 ***
	(16.668)	*(18.879)*	*(28.270)*	*(21.753)*	*(29.848)*
Outsourcing	-1.2850 *	-9.2675 ***	-1.7367	-8.3219 ***	-6.1810 ***
	(0.625)	*(0.969)*	*(1.204)*	*(1.001)*	*(1.225)*
E-Commerce Intensity (County)	109464.5000 ***	129924.0000 ***	134048.3000 ***	93900.1300 ***	91858.5000 ***
	(5037.384)	*(6120.681)*	*(5869.787)*	*(4713.862)*	*(5673.518)*
E-Commerce Intensity (NAICS)	41400.7500 **	153549.9000 ***	158389.8000 ***	86099.9400 ***	76988.4100 ***
	(15836.490)	*(12925.480)*	*(13965.570)*	*(12224.100)*	*(15087.690)*
Urban/Rural	5797.7280 **	1514.8110	3442.2250	-250.2469	-3242.9050
	(1847.632)	*(2738.961)*	*(3334.262)*	*(3175.188)*	*(3657.654)*
Broadband Competition	5.9630	-8.4576 ***	-2.5706	-3.3190	-9.7155 **
	(3.762)	*(2.466)*	*(2.675)*	*(2.764)*	*(3.105)*
Observations	17769	17769	17769	17769	17769
R^2	0.1227	0.1435	0.4894	0.3555	0.2831

The coefficient estimates also grow noisier in this new model, occasionally losing statistical significance across each year's individual model. Nonetheless, the key features of the last chapter survive the new model specification. E-commerce is still significant in establishments with more total output, so establishment size did lead to quicker adoption and greater success. Export-oriented establishments and those with more production employment saw the bigger increases in e-commerce activity. The geographical area context still matters, with establishments in areas rich with e-commerce activity turning to e-commerce in greater numbers – and the same could be said of the industrial context.

The observed effect of wages and employment still remains, despite a model specification that allowed for the possibility the causal effect could run in the opposite direction. Establishments paying higher wages jumped into e-commerce after the dot-com bust; they did not simply raise their wages because they were using e-commerce. The pattern observed in Table 5.1 is not nearly as clean or as strong as the models in chapter 4 indicated. Therefore, taking into account the endogenous relationship between the variables did make a difference by preventing an inflated estimate of the effect of establishment wages. Similarly, establishments with fewer employees given their overall output turned to e-commerce at a higher rate. Presuming my model successfully captured the endogeneity within these data, I can now have more confidence than I did in the last chapter that e-commerce intensity really did tend to emerge from (rather than simply create) high-wage, small-employment establishments.

The pattern followed by the variables that measure e-commerce intensity by county and by manufacturing sector is a fascinating one. First, both variables are significant and positive for all five years covered. Location in a county oriented toward e-commerce consistently predicts the establishment's behavior. Existence in an industry oriented toward e-commerce also consistently predicts that the establishment will follow suit. However, both of these contextual effects follow a consistent pattern – the same basic pattern – with regard to the strength of their relationship with e-commerce intensity. The contextual effect starts off relatively weak, as does the explanatory power of the model; presumably early adoption contained a large random component based on the quirky preferences, experiments, or expertise of the establishment's management. By 2002 and 2003, the contextual effects had grown much stronger; nearby businesses and industry competitors followed the lead of the early adopters. However, the results for 2004 and 2005, demonstrate that the growing commonality of e-commerce has weakened those contextual effects again, because more establishments in industries and counties that are not especially rich in e-commerce have started picking up the business model.

Neither the urban/rural variable nor the broadband variable can be credited with much explanatory power. They fail to achieve statistical significance in most years, and the coefficient on the latter variable goes in the wrong direction. The pattern in terms of an establishment rural or urban location is interesting, if I could have any confidence in it. Initially, e-commerce is significant in urban areas, but over time the rural areas thought best able to benefit from widening their potential market are the ones successfully pursuing it more. However, trying to improve the precision of my testing of this hypothesis was not possible given my limited access to the data and limited ability to experiment with variable measurement. Testing this idea better will have to be a goal of future research.

Table 5.2 gives a second look at these relationships as tested within a 3SLS model, using the economic area as the areal unit of measure. However, analysis of the results at the higher aggregate scale adds little interesting information to those results presented above. The independent variables all exhibit roughly the same relationship. However, the effect of the manufacturing context, when measured at the economic area, along with the loss of the urban/rural variable, results in a model with poorer fit to the data. Counties once again seem the superior areal unit for understanding how establishments affect each other's e-commerce activity.

Table 5.2: Three Stage Least Squares with Dependent Variable E-commerce

Areal Unit of Measure: Economic Area	E-Commerce 1999	E-Commerce 2002	E-Commerce 2003	E-Commerce 2004	E-Commerce 2005
Total Employment	150.0820 ***	-659.1281 ***	-73.4705 **	-305.4008 ***	-587.5994 ***
	(15.464)	*(23.529)*	*(25.843)*	*(24.792)*	*(28.831)*
Establishment Outputs	0.3901 ***	0.0885 *	0.5725 ***	0.2900 ***	0.3416 ***
	(0.031)	*(0.045)*	*(0.052)*	*(0.044)*	*(0.039)*
Wages	-2.1250 ***	14.2761 ***	2.4132 ***	10.6866 ***	15.3079 ***
	(0.324)	*(0.378)*	*(0.385)*	*(0.324)*	*(0.433)*
Exports	0.3819 ***	0.7534 ***	0.6432 ***	0.3384 ***	0.1955 ***
	(0.037)	*(0.046)*	*(0.044)*	*(0.036)*	*(0.048)*
Non-Production Employment	-92.5595 ***	-178.2192 ***	-112.0102 ***	-413.6742 ***	-430.7498 ***
	(15.995)	*(19.019)*	*(27.378)*	*(22.984)*	*(30.186)*
Outsourcing	-1.1013	-8.7909 ***	-2.0155	-5.5091 ***	-4.0193 ***
	(0.649)	*(0.969)*	*(1.173)*	*(0.860)*	*(1.036)*
E-Commerce Intensity (EA)	71841.7600 ***	85641.6500 ***	99284.6900 ***	65980.2600 ***	67632.9200 ***
	(8555.361)	*(8899.849)*	*(8286.499)*	*(7421.029)*	*(8786.133)*
E-Commerce Intensity (NAICS)	31261.6000 *	166103.8000 ***	163698.1000 ***	89154.4400 ***	75941.9000 ***
	(15177.890)	*(13122.630)*	*(13744.190)*	*(12580.670)*	*(15364.720)*
Broadband Competition	0.0044 *	-0.0003 **	0.0002	-0.0006	-0.0025 *
	(0.002)	*(0.000)*	*(0.001)*	*(0.001)*	*(0.001)*
Observations	17769	17769	17769	17769	17769
R^2	0.1106	0.1279	0.4909	0.4033	0.3428

Predicting Establishment Employment and Wages

The primary benefit of this new set of models is that they allow me to consider the effects of pursuing e-commerce rather than only the causes. Two of the hypotheses introduced in chapter 2 apply to these additional dependent variables within the simultaneous-equations model:

Hypothesis 8: After e-commerce adoption the total number of employees in an establishment will decrease.

and

Hypothesis 9: After e-commerce adoption, employee wages will increase as more highly skilled employees will be needed to implement e-commerce technologies.

Table 5.3 provides the second part of the 3SLS model where establishment employment is the dependent variable.

Table 5.3: Three Stage Least Squares with Dependent Variable Total Employment

Areal Unit of Measure: County Level	Total Employment 1999	Total Employment 2002	Total Employment 2003	Total Employment 2004	Total Employment 2005
E-Commerce	0.0000	-0.0002 ***	-0.0002 ***	-0.0003 ***	-0.0003 ***
	(0.000)	*(0.000)*	*(0.000)*	*(0.000)*	*(0.000)*
Establishment Outputs	-0.0008 ***	-0.0001 ***	0.0005 ***	-0.0001 ***	-0.0001 ***
	(0.000)	*(0.000)*	*(0.000)*	*(0.000)*	*(0.000)*
Wages	0.0199 ***	0.0175 ***	0.0183 ***	0.0176 ***	0.0170 ***
	(0.000)	*(0.000)*	*(0.000)*	*(0.000)*	*(0.000)*
Outsourcing	0.0003	-0.0013 **	-0.0024 **	-0.0038 ***	-0.0017 ***
	(0.000)	*(0.000)*	*(0.001)*	*(0.001)*	*(0.000)*
Education	0.0000	0.0000	0.0000	0.0000	0.0000
	(0.000)	*(0.000)*	*(0.000)*	*(0.000)*	*(0.000)*
Unemployment	-0.5723	0.4442	-0.1241	-0.6766	-0.5184
	(1.176)	*(2.098)*	*(3.857)*	*(3.898)*	*(2.286)*
Employment in Manufacturing	0.0000	0.0001	0.0001 *	0.0001	0.0000
	(0.000)	*(0.000)*	*(0.000)*	*(0.000)*	*(0.000)*
Married Households	0.0000	-0.0001	0.0000	0.0000	0.0000
	(0.000)	*(0.000)*	*(0.000)*	*(0.000)*	*(0.000)*
Establishment Labor Costs	-0.5637	0.0208	-0.3202	-0.0142	-0.0666
	(0.314)	*(0.065)*	*(0.221)*	*(0.116)*	*(0.076)*
Observations	17769	17769	17769	17769	17769
R^2	0.8534	0.8869	0.8322	0.8356	0.8375

Testing Hypothesis 8

Hypothesis 8: After e-commerce adoption the total number of employees in an establishment will decrease.

As would be expected, using e-commerce initially had no effect on establishment employment, but starting in 2002, e-commerce usage increasingly appears to lead to lower employment levels. While hardly definitive proof that e-commerce allowed establishments to trim out the parts of the workforce (non-production employees), the results of the model are fully consistent with that idea.

Otherwise, the combined effects of outputs and wages are interesting in their own right. In previous discussion, both wages and employment appeared in my models. Wages, after controlling for total employment, means something different from the raw variable, total wages. Essentially, it means how much the typical worker is getting paid. The model in Table 5.3, though, does not have a control for employment because it is predicting employment. Total wages and total outputs are going to be rival measures of establishment size, and in this model, the wages measure seems to capture that size effect. The greater the payroll in the establishment, the more people they (can) hire, a pattern that's strong and significant – but no longer important beyond serving as a control variable. Once I take into account this based payroll-to-employment effect, though, I see that the relationship for outputs is weak and inconsistent, probably just false significance bred by the large sample size. It is possible for these establishments to produce a lot of output without really requiring a sizable increase in employment to do that.

The only other variable to provide significant assistance in predicting employment levels is the outsourcing variable, which had proved counter-intuitive to the hypothesized relationship in the equations predicting e-commerce. In the employment portion of the model, though, it behaves exactly as expected. Outsourcing is a substitute for adding to one's own workforce, and establishments that outsource more are also establishments that, controlling for their overall output, hire fewer employees.

The distinction between the equations in 5.3 and in 5.4 provides little additional insight. The only difference offered as I move from measures at the county scale to that of the economic area is that employment in manufacturing—a variable indicative of manufacturing activity in the area-- does come closer to approaching statistical significance in the model using economic areas. However, the patterns are not strong or consistent enough to read much into it. The two approaches perform pretty much the same way, this time even in terms of model fit. Table 5.4 is included below.

Table 5.4: Three Stage Least Squares with Dependent Variable Total Employment

Areal Unit of Measure: Economic Area	Total Employment 1999		Total Employment 2002		Total Employment 2003		Total Employment 2004		Total Employment 2005	
E-Commerce	0.0000		-0.0003	***	-0.0002	***	-0.0003	***	-0.0003	***
	(0.000)		*(5.526)*		*(0.000)*		*(0.000)*		*(0.000)*	
Establishment Outputs	-0.0008	***	-0.0001	**	-0.0005	***	-0.0002	***	-0.0001	***
	(0.000)		*(0.008)*		*(0.000)*		*(0.000)*		*(0.000)*	
Wages	0.0197	***	0.0174	***	0.0182	***	0.0176	***	0.0169	***
	(0.000)		*(0.110)*		*(0.000)*		*(0.000)*		*(0.000)*	
Outsourcing	0.0001		-0.0007	*	-0.0017	**	-0.0025	***	-0.0011	***
	(0.000)		*(0.024)*		*(0.001)*		*(0.001)*		*(0.000)*	
Education	0.0000		0.0000		0.0000		0.0000		0.0000	
	(0.000)		*(0.000)*		*(0.000)*		*(0.000)*		*(0.000)*	
Unemployment	2.1618		2.0789		3.8782		0.1205		-0.1045	
	(2.829)		*(0.099)*		*(5.773)*		*(3.805)*		*(1.036)*	
Employment in Manufacturing	0.0000		0.0000	***	0.0000	*	0.0000	*	0.0000	**
	(0.000)		*(0.000)*		*(0.000)*		*(0.000)*		*(0.000)*	
Married Households	0.0000		0.0000	***	0.0000		0.0000	**	0.0000	**
	(0.000)		*(0.000)*		*(0.000)*		*(0.000)*		*(0.000)*	
Establishment Labor Costs	-0.6013		0.0433		-0.2669		-0.0161		-0.0626	
	(0.350)		*(0.000)*		*(0.199)*		*(0.107)*		*(0.071)*	
Observations	17769		17769		17769		17769		17769	
R^2	0.8561		0.8856		0.8326		0.8374		0.8353	

Testing Hypothesis 9

Hypothesis 9: After e-commerce adoption, employee wages will increase as more highly skilled employees will be needed to implement e-commerce technologies.

It has been demonstrated that e-commerce corresponds to lower employment levels, other things equal. But does it bring the positive flip side: Higher wages for the more-capable, more-efficient workers who remain? Tables 5.5 and 5.6 look to determine the answer to that question.

Table 5.5: Three Stage Least Squares with Dependent Variable Establishment Wages

Areal Unit of Measure: County Level	Wages 1999		Wages 2002		Wages 2003		Wages 2004		Wages 2005	
Total Employment	49.4218	***	55.7365	***	52.1572	***	55.7858	***	58.7989	***
	(0.201)		*(0.264)*		*(0.308)*		*(0.260)*		*(0.251)*	
Establishment Outputs	0.0457	***	0.0188	***	0.0538	***	0.0278	***	0.0126	***
	(0.002)		*(0.002)*		*(0.002)*		*(0.001)*		*(0.001)*	
E-Commerce Sales	-0.0072	***	0.0073	***	-0.0045	***	0.0080	***	0.0118	***
	(0.002)		*(0.001)*		*(0.001)*		*(0.001)*		*(0.001)*	
Education	0.0025	***	0.0029	***	0.0034	***	0.0037	***	0.0032	***
	(0.000)		*(0.001)*		*(0.001)*		*(0.001)*		*(0.001)*	
Minimum Wage	-49.3727		-23.7430		-2.4279		67.8515		38.7527	
	(105.756)		*(52.625)*		*(79.537)*		*(69.298)*		*(38.090)*	
Population Density	0.0052		0.0124		0.0366	*	0.0472	**	0.0268	*
	(0.005)		*(0.012)*		*(0.019)*		*(0.020)*		*(0.012)*	
County Wages	0.0000		0.0000		0.0000		0.0000	*	0.0000	
	(0.000)		*(0.000)*		*(0.000)*		*(0.000)*		*(0.000)*	
County Wages in Manufacturing	0.0000		0.0000		0.0000		0.0000		0.0000	
	(0.000)		*(0.000)*		*(0.000)*		*(0.000)*		*(0.000)*	
Labor Productivity	1274.1280		-32.1703		730.3746		60.7899		120.0478	
	(615.036)		*(116.702)*		*(561.746)*		*(271.155)*		*(143.605)*	
Observations	17769		17769		17769		17769		17769	
R^2	0.8798		0.8923		0.8502		0.8677		0.8592	

Table 5.6: Three Stage Least Squares with Dependent Variable Establishment Wages

Areal Unit of Measure: Economic Area	Wages 1999		Wages 2002		Wages 2003		Wages 2004		Wages 2005	
Total Employment	49.6786	***	56.4303	***	52.8884	**	56.3928	***	59.1670	***
	(0.231)		*(0.264)*		*(0.299)*		*(0.252)*		*(0.243)*	
Establishment Outputs	0.0481	***	0.0140	***	0.0495	***	0.0239	***	0.0095	***
	(0.002)		*(0.002)*		*(0.002)*		*(0.001)*		*(0.001)*	
E-Commerce Sales	-0.0134	***	0.0101	***	-0.0023	**	0.0101	***	0.0139	***
	(0.002)		*(0.001)*		*(0.001)*		*(0.324)*		*(0.001)*	
Education	0.0000		0.0000	*	0.0000		0.0000		0.0000	
	(0.000)		*(0.000)*		*(0.000)*		*(0.000)*		*(0.000)*	
Minimum Wage	-49.2131		1.5999		-8.4982		69.3308		39.7103	
	(125.388)		*(49.828)*		*(78.634)*		*(67.544)*		*(37.203)*	
Population Density	-0.0189		0.0015		0.0933		0.1694	*	0.1002	*
	(0.051)		*(0.045)*		*(0.076)*		*(0.074)*		*(0.049)*	
County Wages	0.0000		0.0000	*	0.0000		0.0000		0.0000	
	(0.000)		*(0.000)*		*(0.000)*		*(0.000)*		*(0.000)*	
County Wages in Manufacturing	0.0000		0.0000	*	0.0000		0.0000		0.0000	
	(0.000)		*(0.000)*		*(0.000)*		*(0.000)*		*(0.000)*	
Labor Productivity	1426.6600	*	-68.9358		732.4904		61.6755		112.7580	
	(694.080)		*(113.733)*		*(543.350)*		*(256.469)*		*(131.363)*	
Observations	17769		17769		17769		17769		17769	
R^2	0.8756		0.8911		0.8532		0.8675		0.8573	

The simple answer is: No. Based on the model outputs, I cannot say with confidence that those establishments that adopt e-commerce and start to exhibit lower employment levels also systematically increase the wages of their employees. Controlling for overall employment, an increase in economic output does lead to higher wages. When the establishment's doing well with its sales, it appears either to hire more-expensive employees or to pay existing employees better. However, using the avenue of e-commerce does not appear to reveal any reliable difference. Sometimes establishments with higher e-commerce usage appear to pay less, other things equal, than other establishments (1999, 2003). Other years, the establishments using e-commerce appear to pay more (2002, 2004, 2005). Most likely, this is random noise, and the statistical model is tricked into concluding it's statistically significant due to the massive sample size. My results provide little reason for employees to view innovation in e-commerce as a benefit. Their establishment might start shrinking in size, but with no reliable expectation of an increase in pay resulting from it.

Other portions of the wage model either point in the theorized direction or fail to achieve statistical significance. Other things being equal, an educated workforce successfully commands higher wages, and controlling for that effect, all of the other wage-based indicators fail to show much independent predictive power. Establishments operating in high-density areas also show some tendency to pay out more, perhaps due to the higher cost of living faced by workers.

Interestingly, this portion of the model reveals the one place where the distinction between counties and economic areas matters to the estimation, and matters significantly. County education levels were strong and consistent predictors of the wages paid out by establishments, but education levels in the economic area are not helpful at all. Only once does the education variable even hint at statistical significance in Table 5.6. It is an important difference, but it only confirms the same pattern in these two chapters. The county appears to be an important economic and political unit where the establishments in my sample operate. Aggregating to the economic area as the areal unit of observation hurts the model estimation.

Model 2 Outcomes

Overall, the 3SLS model adds an interesting perspective beyond what can be inferred from the SUR model. The contextual variables (e-commerce intensity in defined geographical area and e-commerce intensity in a manufacturing subsector) are both positive and significant. A manufacturing establishment's location in a county oriented toward e-commerce predicts that the establishment will also adopt e-commerce. If the establishment is part of a manufacturing subsector where e-commerce use is high, then that establishment will follow suit. The later contextual finding does offer support concerning knowledge spillovers occurring between industries, despite the lack of physical proximity.

The models presented in this chapter also provide evidence that e-commerce integration in U.S manufacturing establishments does lead to lower employment levels. Replacing workers with automated systems is nothing new, but previous research has not been able to show a link between e-commerce adoption and workers. Consistent with the previous finding is the relationship between outsourcing and employment. The 3SLS model suggests that outsourcing is also a substitute for hiring one's own workforce.

Essentially, establishments that outsource more are also establishments that, controlling for their overall output, hire fewer employees. Both of these findings provide insight as to why the number of manufacturing workers continues to decline in the U.S.

Lastly, the results from the 3SLS cannot support the supposition in Hypothesis 9 that wages will increase for the higher skilled employees needed to implement e-commerce. My results provide little reason to hope that adopting e-commerce technologies will result in pay increases. Establishments that adopt e-commerce may have fewer employees, but those resources are not being invested in the workers still employed.

6. Conclusions

As e-commerce adoption and integration began to emerge 15 years ago as a business strategy, some scholars hoped it would be a technology that would substantially alter economic relations. E-commerce could allow establishments located in rural areas the chance to compete with those located in urban areas. Small-and-medium sized establishments in economically distressed regions would be able to outperform, due to their lower wages and operating costs, larger establishments whose strength depended on many of the positive externalities afforded by more urban economies. Employment and wages might rise in establishments adopting e-commerce, relative to those that did not adopt e-commerce. However, nothing guaranteed that e-commerce would bring about such economic changes and, in fact, the empirical results in this dissertation suggest the opposite—that far from liberating economic exchange from its traditional patterns, e-commerce has served to ingrain these patterns even more.

The purpose of this dissertation was to evaluate 1) the characteristics of manufacturing establishments that implemented e-commerce when e-commerce began emerging as a business strategy, and 2) once manufacturing establishments adopted e-commerce strategies, what were the effects on establishment employment and wages. The model results presented in chapter 4 and chapter 5 demonstrate the following key findings:

1) Larger, export oriented firms that are co-located geographically with other manufacturing firms using e-commerce and in industries using e-commerce

heavily themselves were more likely to report high e-commerce adoption and intensity during the time period studied.

2) A firm's increased e-commerce usage leads to lower employment levels, with no reliable expectation that wages will increase for those employees remaining for those years included in the analysis.

These results imply that e-commerce has not served to radically alter economic relations for firms located in rural areas, nor has it served as a source of new jobs for the U.S. manufacturing industry. For firms that did adopt and integrate e-commerce activities, I hypothesized that the increase in technological knowledge required to implement these strategies would lead to higher wages for those engaging in these activities. However, I could find no evidence of this scenario either—rather e-commerce tended to lead to fewer employees, and those still employed could not reliably expect an increase in pay to result. In addition to the key results presented above, other interesting empirical findings were presented as well. Table 6.1 provides a review of the nine hypotheses and their outcomes.

Table 6.1: Summary of Hypothesis Statements, Results, and Significance

Hypothesis	Result	Significant
H1: Large U.S. manufacturing establishments will have higher rates of e-commerce adoption	Confirmed	Yes
H2: Exports will be higher among U.S. Manufacturing establishments that use e-commerce	Confirmed	Yes
H3: E-commerce adoption will be higher among establishments that outsource parts of the manufacturing process to contract workers	Not Confirmed	Yes
H4: E-commerce adoption will be higher among U.S. Manufacturing establishments that have higher wage rates for workers	Confirmed	Yes
H5: E-commerce adoption will be higher in urban areas than rural areas	Confirmed	No
H6: E-commerce adoption will be higher among establishments that are co-located near other establishments using e-commerce	Confirmed	Yes
H7: E-commerce adoption will be higher among establishments in industrial sectors where e-commerce adoption is also high.	Confirmed	Yes
H8: After e-commerce adoption the total number of employees in an establishment will decrease.	Confirmed	Yes
H9: After e-commerce adoption, employee wages will increase as more highly skilled employees will be needed to implement e-commerce technologies	Not Confirmed	Yes

As Table 6.1 demonstrates, the data analysis developed in this dissertation was able to confirm the majority of hypothesized relationships developed in chapter 2. However, there are several hypotheses that were not confirmed. I was unable to confirm Hypothesis 3, where e-commerce adoption was NOT higher among establishments that outsourced parts of manufacturing process to contract workers. The unexpected pattern is statistically significant in most of the models included. Certainly this is an area that future research could try and explore to explain this counter intuitive finding. I was also unable to confirm Hypothesis 9; that employee wages would increase after the implementation of e-commerce. My results showed that employee wages were positive in some years and negative in others, while remaining statistically significant across all years. Again, I suspect this result is based on the large sampling size of my data. However, determining how e-commerce integration affects worker wages is important. Understanding how and if employees are compensated for the technological knowledge needed to operate e-commerce systems has larger implications for how scholars have traditionally viewed the relationship between technology and wages.

Avenue for Future Research

In addition to the hypothesized relationships directly tested in this dissertation, supplementary results emerged pertaining to the ongoing debates on geographical area and knowledge/innovation spillovers. Using two separate scales to test the effect of e-commerce intensity provides supporting evidence specifically for the current debates on spatial proximity and knowledge diffusion. Essentially, an establishment's location in a county oriented toward e-commerce consistently helped to predict the establishment's behavior toward e-commerce. The county effect of e-commerce adoption starts off relatively weak in 1999, but by 2002 and 2003, the effect of being located in a county with high e-commerce intensity had grown much stronger; nearby businesses and industry competitors followed the lead of the early adopters. However, the results for 2004 and 2005, demonstrate that the growing commonality of e-commerce has weakened those contextual effects again, because more establishments in industries and counties that are not especially rich in e-commerce have started picking up the business model.

A second analysis of the data provides another look at the relationships between location and orientation toward e-commerce. However, the second analysis uses the economic area as the areal unit of measure. At the broader geographic scale, the spillover effect of e-commerce resulted in a poorer fit to the data. Ultimately, counties were the superior areal unit for understanding how establishments affect each other's e-commerce activity. Empirically demonstrating the stronger spillover effect at the smaller geographical area and over the 6-year time frame under analysis certainly adds more support to the body of knowledge supporting geographical proximity and knowledge spillovers and innovation. Ultimately, further research is needed, but the results of this dissertation do provide an interesting start in the exploration of the timing and geography of innovation diffusion.

Despite the theoretically interesting debates pertaining to geographical area and knowledge/innovation spillovers, the primary contribution of this dissertation pertain to the how capital investment is (again) replacing labor in the U.S. manufacturing industry. As e-commerce continues to spread throughout the U.S. manufacturing industry, the outlook for workers and worker wages isn't an overall positive one—it seems that there will be fewer workers in establishment that are required to use advanced technologies without compensation for that specialized knowledge. These findings also do not provide a positive outlook for a "spatially equitable landscape" to develop via the dissemination of e-commerce in the U.S. manufacturing industry. Rather, the results suggest that the application of e-commerce in the U.S. manufacturing industry will continue to reinforce the geographical advantages of firms in urban areas verses those located in more rural areas—that the internet and e-commerce are very unlikely to be the economic development magical wand early pundits had hoped it could be.

APPENDIX A

Stata Equations

Due to the restrictions at the Census Bureau Research Data Center, I was unable to remove a copy of the text file or .do file that would have shown all Stata programming commands used in this dissertation. However, all data manipulations to the raw Census data and the outside data I supplied were recorded and supplied to Census analysts for review. I was able to remove the Stata syntax used to generate the models in this dissertation; they are more fully explained and presented below.

Setting up the Stata equation to run the seemingly unrelated regression (SUR) model for the years 1999, 2002, 2003, 2004, and 2005 involved setting up five equations, one for each year: For example, the equation for predicting e-commerce sales in 1999 requires one dependent variable and 10 independent variables.

sureg (e-commerce sales 1999) (total employment 1999) (establishment outputs 1999) (worker wages 1999) (exports 1999) (number of non-production workers 1999) (outsourcing 1999) (e-commerce intensity by county 1999) (e-commerce intensity by NAICS 1999) (urban/rural 2000) (broadband competition 1999)

When the other analysis years are also incorporated (as they are in the SUR model) there are 55 variables across 5 equations.

The final Stata syntax for the SUR equation is presented below:

sureg (e-commerce sales 1999) (total employment 1999) (establishment outputs 1999) (worker wages 1999) (exports 1999) (number of non-production workers 1999) (outsourcing 1999) (e-commerce intensity by county 1999) (e-commerce intensity by NAICS 1999) (urban/rural 2000) (broadband competition 1999) sureg (e-commerce sales 1999) (total employment 1999) (establishment outputs 1999) (worker wages 1999) (exports 1999) (number of non-production workers 1999) (outsourcing 1999) (e-commerce intensity by county 1999) (e-commerce intensity by NAICS 1999) (urban/rural 2000) (broadband competition 1999) (e-commerce sales 2002) (total employment 2002) (establishment outputs 2002) (worker wages 2002) (exports 2002) (number of non-production workers 2002) (outsourcing 2002) (e-commerce intensity by county 2002) (e-commerce intensity by NAICS 2002) (urban/rural 2000) (broadband competition 2002) (e-commerce sales 2003) (total employment 2003) (establishment outputs 2003) (worker wages 2003) (exports 2003) (number of non-production workers 2003) (outsourcing 2003) (e-commerce intensity by county 2003) (e-commerce intensity by NAICS 2003) (urban/rural 2000) (broadband competition 2003) (e-commerce sales 2004) (total employment 2004) (establishment outputs 2004) (worker wages 2004) (exports 2004) (number of non-production workers 2004) (outsourcing 2004) (e-commerce intensity by county 2004) (e-commerce intensity by NAICS 2004) (urban/rural 2000) (broadband competition 2004) (e-commerce sales 2005) (total employment 2005) (establishment outputs 2005) (worker wages 2005) (exports 2005) (number of non-production workers 2005) (outsourcing 2005) (e-commerce intensity by county 2005) (e-commerce intensity by NAICS 2005) (urban/rural 2000) (broadband competition 2005)

Although the Stata programming window is equipped to handle the large number of variables for the equations in the SUR model, it does not contain enough space 135 variables necessary for the 3SLS model. Therefore, I needed to convert the data to an analyzable form using global macros. Global macros are used to store items parametric to a program that is to be embedded in all files names created by the program (Baum 2009).

The following global macros were defined:

global ecom_sales99 “(qec99: te99 va99 sw99 exp99 oe99 cw99 EC_by_County99 EC_by_NAICS99 ur_rural00 companies99)”

- using the same formula as above globals were written for ec02, ec03, ec04, and ec05

global te99 “(qte99: ecom_sales99 va99 sw99 cw99 as_edu00 cou_uemp99 cem1999 marr_hh00 swva99)”

- using the same formula as above globals were written for te02, te03, te04, te05 and sw05

global sw99 “(qsw99: te99 va99 ecom_sales99 as_edu00 mw1999 popden99 ctw1999 cwm1999 spe99)

- using the same formula as above globals were written for sw02, sw03, sw04, and sw05

Thus the final equation entered into the Stata programming window for the 3SLS model:

eg3 $ecom_sales99 $ecom_sales02 $ecom_sales03 $ecom_sales04 $ecom_sales05 $te99 $te02 $te03 $te04 $te05 $sw99 $sw02 $sw03 $sw04 $sw05, endog (as_edu00 cw99 cw02 cw03 cw04 cw05 va99 va02 va03 va04 va05)

When the same model as above is run without the endog option, reg3 will assume that that there are no endogenous variables in the system and produce sureg estimates.

APPENDIX B

Raw Stata Output

Model 1: Three-stage least-squares regression with endogenous variables and several county level measures.

Equation	Obs	Parms	RMSE	"R-sq"	chi2	P
qec99	17769	10	114077.2	0.1227	3898.59	0.0000
qec02	17769	10	212695.6	0.1435	8199.79	0.0000
qec03	17769	10	200901.8	0.4894	7176.84	0.0000
qec04	17769	10	241378.9	0.3555	7497.80	0.0000
qec05	17769	10	285913.1	0.2831	6527.93	0.0000
qte99	17769	9	210.8195	0.8534	133045.33	0.0000
qte02	17769	9	174.6045	0.8869	131168.38	0.0000
qte03	17769	9	203.7831	0.8322	74284.08	0.0000
qte04	17769	9	197.4312	0.8356	57089.59	0.0000
qte05	17769	9	193.4399	0.8375	94037.30	0.0000
qsw99	17769	9	10726.47	0.8798	156554.25	0.0000
qsw02	17769	9	9934.609	0.8923	163947.58	0.0000
qsw03	17769	9	11730.82	0.8502	104058.57	0.0000
qsw04	17769	9	11010.75	0.8677	126403.24	0.0000
qsw05	17769	9	11307.82	0.8592	123104.40	0.0000

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
qec99						
te99	167.1658	16.6014	10.07	0.000	134.6277	199.7039
va99	.3817081	.0316283	12.07	0.000	.3197177	.4436985
sw99	-2.418184	.3384428	-7.15	0.000	-3.08152	-1.754848
exp99	.4157375	.0367071	11.33	0.000	.3437929	.4876821
oe99	-97.13067	16.66801	-5.83	0.000	-129.7994	-64.46196
cw99	-1.285028	.6253226	-2.05	0.040	-2.510638	-.0594183
EC_by_Cou~99	109464.5	5037.384	21.73	0.000	99591.43	119337.6
EC_by_Nai~99	41400.75	15836.49	2.61	0.009	10361.8	72439.71
ur_rural00	5797.728	1847.632	3.14	0.002	2176.435	9419.021
companies99	5.962977	3.762081	1.59	0.113	-1.410566	13.33652
_cons	-41074.72	2680.155	-15.33	0.000	-46327.73	-35821.71
qec02						
te02	-645.9089	24.80593	-26.04	0.000	-694.5276	-597.2902
va02	.1429008	.0450333	3.17	0.002	.054637	.2311645
sw02	13.80473	.3908999	35.32	0.000	13.03858	14.57088
exp02	.7300266	.0460979	15.84	0.000	.6396764	.8203769
oe02	-164.7854	18.87913	-8.73	0.000	-201.7878	-127.783
cw02	-9.267462	.9688176	-9.57	0.000	-11.16631	-7.368615
EC_by_Cou~02	129924	6120.681	21.23	0.000	117927.7	141920.3
EC_by_Nai~02	153549.9	12925.48	11.88	0.000	128216.5	178883.4
ur_rural00	-1514.811	2738.961	-0.55	0.580	-6883.076	3853.454
companies02	-8.457574	2.46622	-3.43	0.001	-13.29128	-3.623872
_cons	14335.57	3360.804	4.27	0.000	7748.521	20922.63
qec03						
te03	-20.70397	27.0923	-0.76	0.445	-73.8039	32.39597
va03	.6055633	.0539472	11.23	0.000	.4998287	.7112979
sw03	.9991546	.4074224	2.45	0.014	.2006213	1.797688
exp03	.7103856	.0460216	15.44	0.000	.620185	.8005863
oe03	-72.85359	28.26996	-2.58	0.010	-128.2617	-17.44548
cw03	-1.736723	1.203637	-1.44	0.149	-4.095809	.6223619
EC_by_Cou~03	134048.3	5869.787	22.84	0.000	122543.7	145552.9
EC_by_Nai~03	158389.8	13965.57	11.34	0.000	131017.8	185761.8
ur_rural00	3442.225	3334.262	1.03	0.302	-3092.809	9977.259
companies03	-2.570639	2.674584	-0.96	0.336	-7.812728	2.67145
_cons	-61184.75	4040.76	-15.14	0.000	-69104.5	-53265.01
qec04						
te04	-372.3619	23.77977	-15.66	0.000	-418.9693	-325.7544

va04	.4008548	.0455531	8.80	0.000	.3115724	.4901371
sw04	10.84465	.3320334	32.66	0.000	10.19388	11.49542
exp04	.3129261	.0357147	8.76	0.000	.2429265	.3829257
oe04	-329.5174	21.75265	-15.15	0.000	-372.1518	-286.8829
cw04	-8.321887	1.001032	-8.31	0.000	-10.28387	-6.359899
EC_by_Cou~04	93900.13	4713.862	19.92	0.000	84661.13	103139.1
EC_by_Nai~04	86099.94	12224.1	7.04	0.000	62141.14	110058.7
ur_rural00	-250.2469	3175.188	-0.08	0.937	-6473.5	5973.007
companies04	-3.318999	2.76361	-1.20	0.230	-8.735575	2.097576
_cons	-28237.22	4041.823	-6.99	0.000	-36159.05	-20315.39
qec05						
te05	-717.0774	29.54987	-24.27	0.000	-774.9941	-659.1607
va05	.3625329	.0412133	8.80	0.000	.2817563	.4433096
sw05	16.67118	.4537156	36.74	0.000	15.78191	17.56045
exp05	.2068468	.0489638	4.22	0.000	.1108794	.3028142
oe05	-350.1296	29.848	-11.73	0.000	-408.6307	-291.6286
cw05	-6.181024	1.22543	-5.04	0.000	-8.582823	-3.779225
EC_by_Cou~05	91858.5	5673.518	16.19	0.000	80738.61	102978.4
EC_by_Nai~05	76988.41	15087.69	5.10	0.000	47417.07	106559.7
ur_rural00	-3242.905	3657.654	-0.89	0.375	-10411.77	3925.965
companies05	-9.715544	3.104677	-3.13	0.002	-15.8006	-3.63049
_cons	-6487.866	5205.524	-1.25	0.213	-16690.51	3714.774
qte99						
ecom_sales99	.0000322	.0000379	0.85	0.395	-.0000421	.0001065
va99	-.0007937	.0000319	-24.91	0.000	-.0008561	-.0007312
sw99	.0199201	.0000803	248.20	0.000	.0197628	.0200774
cw99	.0003105	.0001979	1.57	0.117	-.0000774	.0006985
as_edu00	-.0000458	.0000273	-1.68	0.093	-.0000992	7.70e-06
cou_uemp99	-.5723461	1.176461	-0.49	0.627	-2.878168	1.733475
cem1999	8.74e-06	.0000173	0.50	0.614	-.0000253	.0000427
marr_hh00	-6.77e-06	.0000258	-0.26	0.793	-.0000573	.0000437
swva99	-.5636962	.3141883	-1.79	0.073	-1.179494	.0521016
_cons	102.7838	2.459768	41.79	0.000	97.96277	107.6049
qte02						
ecom_sales02	-.0002447	.0000137	-17.82	0.000	-.0002716	-.0002178
va02	-.0000995	.0000312	-3.19	0.001	-.0001606	-.0000384
sw02	.0174936	.0000879	199.05	0.000	.0173214	.0176659
cw02	-.0013127	.0004391	-2.99	0.003	-.0021732	-.0004521
as_edu00	-6.51e-06	.0000491	-0.13	0.895	-.0001028	.0000898
cou_uemp02	.4442084	2.0984	0.21	0.832	-3.668579	4.556996
cme2002	.0000533	.0000285	1.87	0.061	-2.51e-06	.0001091
marr_hh00	-.0000509	.0000491	-1.04	0.300	-.0001471	.0000453
swva02	.0207882	.0650789	0.32	0.749	-.1067642	.1483406
_cons	89.80932	3.076252	29.19	0.000	83.77998	95.83866
qte03						
ecom_sales03	-.0001738	.0000161	-10.78	0.000	-.0002054	-.0001422
va03	-.0005247	.0000365	-14.37	0.000	-.0005963	-.0004531
sw03	.0183325	.0001063	172.53	0.000	.0181242	.0185407
cw03	-.0024254	.0007705	-3.15	0.002	-.0039356	-.0009152
as_edu00	-.0000469	.0000861	-0.54	0.586	-.0002156	.0001218
cou_uemp03	-.1240924	3.856828	-0.03	0.974	-7.683337	7.435152
cme2003	.0001038	.0000474	2.19	0.029	.0000109	.0001967
marr_hh00	-.0000267	.0000884	-0.30	0.762	-.0001999	.0001465
swva03	-.3202026	.2208068	-1.45	0.147	-.752976	.1125708
_cons	89.17677	5.191327	17.18	0.000	79.00196	99.35159
qte04						
ecom_sales04	-.0003357	.0000126	-26.54	0.000	-.0003604	-.0003109
va04	-.0001439	.0000294	-4.90	0.000	-.0002015	-.0000864
sw04	.0176268	.0001102	159.90	0.000	.0174108	.0178429
cw04	-.0037914	.0007342	-5.16	0.000	-.0052304	-.0023523
as_edu00	-.000041	.0000862	-0.48	0.634	-.0002099	.0001278
cou_uemp04	-.676584	3.897843	-0.17	0.862	-8.316216	6.963048
cme2004	.0000809	.0000464	1.74	0.081	-.0000101	.0001719
marr_hh00	-.0000285	.0000888	-0.32	0.748	-.0002026	.0001456
swva04	-.0141748	.116377	-0.12	0.903	-.2422695	.2139199
_cons	80.12718	5.366405	14.93	0.000	69.60922	90.64514
qte05						
ecom_sales05	-.0002822	.000011	-25.65	0.000	-.0003038	-.0002606
va05	-.000085	.00002	-4.25	0.000	-.0001242	-.0000458
sw05	.0169672	.0000793	213.90	0.000	.0168117	.0171227
cw05	-.0017067	.0004334	-3.94	0.000	-.0025562	-.0008572
as_edu00	-.0000233	.0000505	-0.46	0.644	-.0001223	.0000756
cou_uemp05	-.5184169	2.286091	-0.23	0.821	-4.999073	3.962239
cme2005	.0000366	.000031	1.18	0.238	-.0000242	.0000973
marr_hh00	-.0000335	.0000508	-0.66	0.510	-.0001331	.0000662

```
       swva05 |  -.0666365   .0760941    -0.88   0.381    -.2157782    .0825053
        _cons |   76.85737   3.386933    22.69   0.000      70.2191    83.49564
-------------+----------------------------------------------------------------
qsw99        |
         te99 |   49.42182    .201205   245.63   0.000     49.02747    49.81618
         va99 |   .0457266   .0015187    30.11   0.000       .04275    .0487031
ecom_sales99 |   -.007201   .0019709    -3.65   0.000     -.011064   -.0033381
     as_edu00 |   .0025038   .0004042     6.19   0.000     .0017115     .003296
       mw1998 |  -49.37274   105.7563    -0.47   0.641    -256.6513    157.9059
     popden99 |   .0051613    .004975     1.04   0.300    -.0045894    .0149121
      ctw1999 |   4.28e-07   2.71e-06     0.16   0.875    -4.89e-06    5.74e-06
      cwm1999 |  -7.75e-06   .0000103    -0.75   0.453     -.000028    .0000125
        spe99 |   1274.128   615.0364     2.07   0.038     68.67888    2479.577
        _cons |  -4815.518   557.5394    -8.64   0.000    -5908.275   -3722.761
-------------+----------------------------------------------------------------
qsw02        |
         te02 |   55.73645   .2729016   204.24   0.000     55.20157    56.27132
         va02 |   .0188386   .0016715    11.27   0.000     .0155625    .0221148
ecom_sales02 |   .0072859   .0007872     9.26   0.000     .0057431    .0088288
     as_edu00 |   .0028936   .0005974     4.84   0.000     .0017228    .0040645
       mw2002 |  -23.74303   52.62492    -0.45   0.652     -126.886    79.39991
     popden02 |   .0124478    .012055     1.03   0.302    -.0111795    .0360751
      ctw2002 |  -4.38e-06   4.96e-06    -0.88   0.377    -.0000141    5.35e-06
      cwm2002 |  -.0000128   .0000257    -0.50   0.617    -.0000631    .0000374
        spe02 |  -32.17032   116.7015    -0.28   0.783    -260.9011    196.5605
        _cons |  -4974.655   293.6854   -16.94   0.000    -5550.268   -4399.042
-------------+----------------------------------------------------------------
qsw03        |
         te03 |   52.15724    .307864   169.42   0.000     51.55383    52.76064
         va03 |   .0537666    .001856    28.97   0.000      .050129    .0574043
ecom_sales03 |  -.0044668   .0009368    -4.77   0.000    -.0063029   -.0026307
     as_edu00 |   .0033902   .0008717     3.89   0.000     .0016818    .0050986
       mw2003 |  -2.427892   79.53665    -0.03   0.976    -158.3169    153.4611
     popden03 |   .0366432    .019383     1.89   0.059    -.0013468    .0746333
      ctw2003 |  -8.72e-06   7.84e-06    -1.11   0.266    -.0000241    6.64e-06
      cwm2003 |  -.0000149   .0000388    -0.38   0.702     -.000091    .0000612
        spe03 |   730.3746   561.7457     1.30   0.194    -370.6268    1831.376
        _cons |  -4860.377   437.4989   -11.11   0.000    -5717.859   -4002.895
-------------+----------------------------------------------------------------
qsw04        |
         te04 |   55.78581   .2600844   214.49   0.000     55.27605    56.29557
         va04 |   .0277763   .0013415    20.71   0.000      .025147    .0304056
ecom_sales04 |   .0080069   .0006621    12.09   0.000     .0067092    .0093047
     as_edu00 |   .0037407   .0007918     4.72   0.000     .0021887    .0052926
       mw2004 |   67.85149   69.29767     0.98   0.328    -67.96944    203.6724
     popden04 |   .0472399   .0195237     2.42   0.016     .0089742    .0855057
      ctw2004 |  -.0000144   7.45e-06    -1.93   0.053     -.000029    1.99e-07
      cwm2004 |   .0000278   .0000373     0.75   0.455    -.0000452    .0001009
        spe04 |   60.78987   271.1548     0.22   0.823    -470.6638    592.2436
        _cons |  -5064.828   384.1696   -13.18   0.000    -5817.787   -4311.869
-------------+----------------------------------------------------------------
qsw05        |
         te05 |   58.79889   .2514719   233.82   0.000     58.30601    59.29177
         va05 |   .0125893   .0011384    11.06   0.000     .0103582    .0148205
ecom_sales05 |   .0117702   .0006779    17.36   0.000     .0104416    .0130987
     as_edu00 |   .0032318   .0006032     5.36   0.000     .0020497     .004414
       mw2005 |   38.75267   38.08965     1.02   0.309    -35.90166     113.407
     popden05 |   .0267957   .0121435     2.21   0.027     .0029948    .0505965
      ctw2005 |  -8.18e-06   4.42e-06    -1.85   0.064    -.0000168    4.91e-07
      cwm2005 |   .0000213    .000024     0.89   0.375    -.0000257    .0000682
        spe05 |   120.0478    143.605     0.84   0.403    -161.4129    401.5085
        _cons |  -4790.298   235.7666   -20.32   0.000    -5252.392   -4328.204
------------------------------------------------------------------------------
Endogenous variables:  ecom_sales99 ecom_sales02 ecom_sales03 ecom_sales04
     ecom_sales05 te99 te02 te03 te04 te05 sw99 sw02 sw03 sw04 sw05 as_edu00
     cw99 cw02 cw03 cw04 cw05 va99 va02 va03 va04 va05
```

Model 2: Three-stage least-squares regression with endogenous variables and economic area measures.

Equation	Obs	Parms	RMSE	"R-sq"	chi2	P
qec99ea	17769	9	114860.8	0.1106	3344.15	0.0000
qec02ea	17769	9	214626.8	0.1279	7625.31	0.0000
qec03ea	17769	9	200612.3	0.4909	6680.48	0.0000
qec04ea	17769	9	232256	0.4033	7607.47	0.0000
qec05ea	17769	9	273744	0.3428	6375.46	0.0000
qte99ea	17769	9	208.8628	0.8561	120066.89	0.0000
qte02ea	17769	8	175.6494	0.8856	141429.85	0.0000
qte03ea	17769	9	203.5864	0.8326	94257.21	0.0000
qte04ea	17769	9	196.37	0.8374	79704.14	0.0000
qte05ea	17769	9	194.7415	0.8353	104677.92	0.0000
qsw99ea	17769	9	10909.75	0.8756	141098.65	0.0000
qsw02ea	17769	8	9991.433	0.8911	165405.74	0.0000
qsw03ea	17769	9	11611.44	0.8532	109442.23	0.0000
qsw04ea	17769	9	11017.67	0.8675	131172.32	0.0000
qsw05ea	17769	9	11384.19	0.8573	126448.96	0.0000

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
qec99ea						
te99	150.082	15.46419	9.71	0.000	119.7728	180.3913
va99	.3900637	.0311283	12.53	0.000	.3290535	.451074
sw99	-2.124951	.3238564	-6.56	0.000	-2.759698	-1.490204
exp99	.3819062	.0371756	10.27	0.000	.3090434	.4547689
oe99	-92.55949	15.99489	-5.79	0.000	-123.9089	-61.2101
cw99	-1.101327	.649479	-1.70	0.090	-2.374283	.1716279
EC_by_EA99	71841.76	8555.361	8.40	0.000	55073.56	88609.96
EC_by_Nai~99	31261.6	15177.89	2.06	0.039	1513.475	61009.72
companies9~A	.0043747	.0020889	2.09	0.036	.0002805	.0084689
_cons	-31023.33	2712.504	-11.44	0.000	-36339.74	-25706.92
qec02ea						
te02	-659.1281	23.52922	-28.01	0.000	-705.2446	-613.0117
va02	.0885266	.0447137	1.98	0.048	.0008894	.1761638
sw02	14.27612	.3778739	37.78	0.000	13.5355	15.01674
exp02	.7534156	.0462863	16.28	0.000	.662696	.8441351
oe02	-178.2192	19.01883	-9.37	0.000	-215.4954	-140.9429
cw02	-8.790878	.9694721	-9.07	0.000	-10.69101	-6.890747
EC_by_EA02	85641.65	8899.849	9.62	0.000	68198.27	103085
EC_by_Nai~02	166103.8	13122.63	12.66	0.000	140384	191823.7
companie~2EA	-.0002827	.0001084	-2.61	0.009	-.0004952	-.0000702
_cons	16804.54	3263.682	5.15	0.000	10407.84	23201.24
qec03ea						
te03	-73.47047	25.84267	-2.84	0.004	-124.1212	-22.81976
va03	.5724888	.0520044	11.01	0.000	.470562	.6744155
sw03	2.413175	.3853944	6.26	0.000	1.657816	3.168534
exp03	.6431909	.0440075	14.62	0.000	.5569378	.7294441
oe03	-112.0102	27.37838	-4.09	0.000	-165.6709	-58.3496
cw03	-2.015543	1.17303	-1.72	0.086	-4.314639	.2835532
EC_by_EA03	99284.69	8286.499	11.98	0.000	83043.45	115525.9
EC_by_Nai~03	163698.1	13744.19	11.91	0.000	136760	190636.2
companie~3EA	.0002491	.000828	0.30	0.764	-.0013737	.0018718
_cons	-55205.8	3962.437	-13.93	0.000	-62972.03	-47439.56
qec04ea						
te04	-305.4008	24.7915	-12.32	0.000	-353.9912	-256.8103
va04	.2899863	.0444016	6.53	0.000	.2029608	.3770118
sw04	10.68661	.3235684	33.03	0.000	10.05243	11.32079
exp04	.3384068	.035673	9.49	0.000	.2684889	.4083246
oe04	-413.6742	22.9837	-18.00	0.000	-458.7214	-368.627
cw04	-5.509096	.8603028	-6.40	0.000	-7.195258	-3.822933
EC_by_EA04	65980.26	7421.029	8.89	0.000	51435.31	80525.21
EC_by_Nai~04	89154.44	12580.67	7.09	0.000	64496.78	113812.1
companie~4EA	-.0006151	.0009628	-0.64	0.523	-.0025022	.001272
_cons	-32470.46	4053.707	-8.01	0.000	-40415.58	-24525.34
qec05ea						
te05	-587.5994	28.8306	-20.38	0.000	-644.1064	-531.0925
va05	.3415531	.0389171	8.78	0.000	.2652769	.4178292
sw05	15.30794	.432961	35.36	0.000	14.45935	16.15653
exp05	.1955167	.0480727	4.07	0.000	.1012959	.2897375
oe05	-430.7498	30.18587	-14.27	0.000	-489.913	-371.5866
cw05	-4.019296	1.036107	-3.88	0.000	-6.050028	-1.988563
EC_by_EA05	67632.92	8786.133	7.70	0.000	50412.41	84853.42

EC_by_Nai~05	75941.9	15364.72	4.94	0.000	45827.6	106056.2
companie~5EA	-.0024967	.0010949	-2.28	0.023	-.0046426	-.0003508
_cons	-16609.23	5369.84	-3.09	0.002	-27133.92	-6084.538
qte99ea						
ecom_sales99	.0000322	.0000464	0.69	0.489	-.0000589	.0001232
va99	-.0007548	.0000371	-20.36	0.000	-.0008274	-.0006821
sw99	.0197302	.0000899	219.42	0.000	.019554	.0199065
cw99	.0001487	.0002353	0.63	0.527	-.0003125	.0006099
as_edu00EA	-8.72e-09	2.63e-08	-0.33	0.740	-6.02e-08	4.28e-08
EA_unemp99	2.161787	2.829173	0.76	0.445	-3.38329	7.706865
cem1999EA	1.15e-08	3.87e-08	0.30	0.766	-6.44e-08	8.74e-08
marr_hh99EA	-1.36e-08	4.23e-08	-0.32	0.748	-9.66e-08	6.94e-08
swva99	-.6013125	.3501791	-1.72	0.086	-1.287651	.085026
_cons	97.22905	4.332527	22.44	0.000	88.73746	105.7206
qte02ea						
ecom_sales02	-.0002736	.0000138	-19.84	0.000	-.0003007	-.0002466
va02	-.0000735	.0000296	-2.49	0.013	-.0001314	-.0000156
sw02	.0174215	.0000823	211.69	0.000	.0172602	.0175828
cw02	-.000703	.0003499	-2.01	0.045	-.0013888	-.0000172
as_edu00EA	-1.20e-08	6.38e-09	-1.87	0.061	-2.45e-08	5.51e-10
EA_unemp02	2.078861	3.561628	0.58	0.559	-4.901801	9.059523
cme2002EA	1.49e-08	4.32e-09	3.44	0.001	6.41e-09	2.34e-08
marr_hh02EA	-5.47e-09	1.65e-09	-3.32	0.001	-8.71e-09	-2.24e-09
swva02	.0433354	.0620348	0.70	0.485	-.0782506	.1649214
_cons	85.67751	5.063865	16.92	0.000	75.75251	95.6025
qte03ea						
ecom_sales03	-.0002221	.0000157	-14.15	0.000	-.0002528	-.0001913
va03	-.0004655	.0000338	-13.76	0.000	-.0005318	-.0003992
sw03	.018193	.0000957	190.14	0.000	.0180055	.0183805
cw03	-.0016599	.0006182	-2.69	0.007	-.0028715	-.0004483
as_edu00EA	-1.49e-08	1.22e-08	-1.22	0.223	-3.89e-08	9.06e-09
EA_unemp03	3.878162	5.772509	0.67	0.502	-7.435748	15.19207
cme2003EA	1.14e-07	5.20e-08	2.19	0.029	1.19e-08	2.16e-07
marr_hh03EA	-3.62e-08	1.96e-08	-1.85	0.065	-7.46e-08	2.25e-09
swva03	-.2668654	.1990199	-1.34	0.180	-.6569374	.1232065
_cons	81.24803	8.012534	10.14	0.000	65.54375	96.95231
qte04ea						
ecom_sales04	-.0003436	.0000117	-29.26	0.000	-.0003666	-.0003206
va04	-.0001549	.0000256	-6.06	0.000	-.000205	-.0001048
sw04	.0175579	.0000922	190.53	0.000	.0173773	.0177385
cw04	-.0024563	.0005082	-4.83	0.000	-.0034523	-.0014603
as_edu00EA	-2.66e-09	1.17e-08	-0.23	0.820	-2.55e-08	2.02e-08
EA_unemp04	.1204721	3.80517	0.03	0.975	-7.337525	7.578469
cme2004EA	1.38e-07	6.14e-08	2.25	0.024	1.78e-08	2.59e-07
marr_hh04EA	-5.61e-08	2.28e-08	-2.46	0.014	-1.01e-07	-1.14e-08
swva04	-.0160615	.1066264	-0.15	0.880	-.2250453	.1929224
_cons	77.34213	5.538578	13.96	0.000	66.48671	88.19754
qte05ea						
ecom_sales05	-.0003061	.0000111	-27.60	0.000	-.0003278	-.0002844
va05	-.0000599	.0000189	-3.18	0.001	-.0000969	-.000023
sw05	.0168867	.0000725	232.87	0.000	.0167445	.0170288
cw05	-.0011029	.00031	-3.56	0.000	-.0017105	-.0004953
as_edu00EA	-1.95e-09	8.69e-09	-0.22	0.822	-1.90e-08	1.51e-08
EA_unemp05	-.1045385	.2799601	-0.37	0.709	-.6532502	.4441733
cme2005EA	1.29e-07	4.75e-08	2.71	0.007	3.58e-08	2.22e-07
marr_hh05EA	-5.35e-08	1.76e-08	-3.04	0.002	-8.80e-08	-1.90e-08
swva05	-.0626101	.0712993	-0.88	0.380	-.2023541	.0771339
_cons	74.24045	1.813873	40.93	0.000	70.68532	77.79557
qsw99ea						
te99	49.6786	.2305391	215.49	0.000	49.22675	50.13044
va99	.0481324	.0017924	26.85	0.000	.0446194	.0516454
ecom_sales99	-.0134085	.0024499	-5.47	0.000	-.0182104	-.0086067
as_edu00EA	7.11e-07	3.83e-07	1.86	0.063	-3.93e-08	1.46e-06
mw1998	-49.21312	125.3881	-0.39	0.695	-294.9693	196.543
popdenEA99	-.0188701	.0514821	-0.37	0.714	-.1197731	.0820329
ctw1999EA	7.32e-10	5.79e-09	0.13	0.899	-1.06e-08	1.21e-08
cwm1999EA	-5.53e-10	2.23e-08	-0.02	0.980	-4.42e-08	4.31e-08
spe99	1426.66	694.0796	2.06	0.040	66.28863	2787.031
_cons	-4752.278	660.6639	-7.19	0.000	-6047.155	-3457.4
qsw02ea						
te02	56.43033	.2636377	214.05	0.000	55.91361	56.94705
va02	.0139885	.0016465	8.50	0.000	.0107614	.0172155
ecom_sales02	.0100986	.0008131	12.42	0.000	.0085049	.0116923
as_edu00EA	8.42e-07	3.98e-07	2.12	0.034	6.19e-08	1.62e-06

```
      mw2002 |   1.599941   49.82797     0.03   0.974    -96.06108    99.26096
  popdenEA02 |   .0015004   .0450489     0.03   0.973    -.0867938    .0897947
   ctw2002EA |   7.99e-10   3.87e-10     2.06   0.039     4.04e-11    1.56e-09
   cwm2002EA |  -5.81e-09   2.70e-09    -2.15   0.031    -1.11e-08   -5.19e-10
       spe02 |  -68.93576   113.7327    -0.61   0.544    -291.8477    153.9761
       _cons |  -5047.516   286.0289   -17.65   0.000    -5608.122    -4486.91
-------------+----------------------------------------------------------------
qsw03ea      |
        te03 |   52.88835   .2991141   176.82   0.000      52.3021    53.47461
        va03 |   .0495395   .0018521    26.75   0.000     .0459094    .0531695
ecom_sales03 |  -.0022902   .0009745    -2.35   0.019    -.0042001   -.0003803
  as_edu00EA |   1.09e-06   6.77e-07     1.61   0.107    -2.36e-07    2.42e-06
      mw2003 |  -8.498241    78.6344    -0.11   0.914    -162.6188    145.6223
  popdenEA03 |   .0932807   .0758586     1.23   0.219    -.0553995    .2419609
   ctw2003EA |  -1.41e-09   4.74e-09    -0.30   0.766    -1.07e-08    7.87e-09
   cwm2003EA |  -1.32e-08   2.64e-08    -0.50   0.617    -6.48e-08    3.85e-08
       spe03 |   732.4904   543.3502     1.35   0.178    -332.4564    1797.437
       _cons |  -4790.519    442.756   -10.82   0.000    -5658.305   -3922.734
-------------+----------------------------------------------------------------
qsw04ea      |
        te04 |   56.39284   .2524947   223.34   0.000     55.89796    56.88772
        va04 |   .0238593   .0013253    18.00   0.000     .0212618    .0264569
ecom_sales04 |   .0100928   .0006821    14.80   0.000     .0087559    .0114296
  as_edu00EA |   3.30e-07   6.38e-07     0.52   0.606    -9.21e-07    1.58e-06
      mw2004 |   69.33083   67.54413     1.03   0.305    -63.05323    201.7149
  popdenEA04 |   .1693591   .0740381     2.29   0.022      .024247    .3144711
   ctw2004EA |  -5.42e-10   4.55e-09    -0.12   0.905    -9.46e-09    8.37e-09
   cwm2004EA |   1.75e-08   2.99e-08     0.59   0.558    -4.12e-08    7.62e-08
       spe04 |   61.67546   256.4692     0.24   0.810     -440.995    564.3459
       _cons |  -5032.907   381.0647   -13.21   0.000     -5779.78   -4286.034
-------------+----------------------------------------------------------------
qsw05ea      |
        te05 |   59.16697   .2433536   243.13   0.000        58.69    59.64393
        va05 |   .0094727   .0011238     8.43   0.000     .0072701    .0116752
ecom_sales05 |   .0139339   .0007007    19.89   0.000     .0125605    .0153072
  as_edu00EA |   2.04e-07   5.13e-07     0.40   0.691    -8.01e-07    1.21e-06
      mw2005 |   39.71026   37.20269     1.07   0.286    -33.20567    112.6262
  popdenEA05 |   .1001565   .0486023     2.06   0.039     .0048977    .1954153
   ctw2005EA |   4.48e-09   3.58e-09     1.25   0.211    -2.53e-09    1.15e-08
   cwm2005EA |  -4.44e-09   2.13e-08    -0.21   0.835    -4.62e-08    3.73e-08
       spe05 |    112.758   131.3628     0.86   0.391    -144.7084    370.2244
       _cons |  -4727.076   231.3423   -20.43   0.000    -5180.499   -4273.653
------------------------------------------------------------------------------
Endogenous variables:  ecom_sales99 ecom_sales02 ecom_sales03 ecom_sales04
     ecom_sales05 te99 te02 te03 te04 te05 sw99 sw02 sw03 sw04 sw05
     as_edu00EA cw99 cw02 cw03 cw04 cw05 va99 va02 va03 va04 va05
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Model 3: Three-stage least-squares regression with SURE option and county level measures

Equation	Obs	Parms	RMSE	"R-sq"	chi2	P
qec99	17769	10	106502.3	0.2353	5502.93	0.0000
qec02	17769	10	163751.2	0.4923	20968.03	0.0000
qec03	17769	10	190302.4	0.5419	27759.08	0.0000
qec04	17769	10	212156.9	0.5021	28067.44	0.0000
qec05	17769	10	255656	0.4268	20592.75	0.0000
qte99	17769	9	192.0475	0.8784	403148.28	0.0000
qte02	17769	9	173.1643	0.8888	579744.13	0.0000
qte03	17769	9	184.0548	0.8631	585239.26	0.0000
qte04	17769	9	181.3421	0.8613	591936.49	0.0000
qte05	17769	9	182.3454	0.8556	524383.21	0.0000
qsw99	17769	9	10624.76	0.8821	421191.80	0.0000
qsw02	17769	9	9869.557	0.8938	599321.45	0.0000
qsw03	17769	9	10890.63	0.8709	599930.76	0.0000
qsw04	17769	9	10885.43	0.8707	604582.16	0.0000
qsw05	17769	9	11131.36	0.8635	547289.62	0.0000

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
qec99						
te99	14.23576	4.302506	3.31	0.001	5.803006	22.66852
va99	.1001685	.0069583	14.40	0.000	.0865306	.1138065
sw99	.9722597	.0841013	11.56	0.000	.8074242	1.137095
exp99	.5356119	.0201465	26.59	0.000	.4961255	.5750983
oe99	-90.59683	5.56034	-16.29	0.000	-101.4949	-79.69876
cw99	-.3192289	.0720534	-4.43	0.000	-.4604509	-.1780068
EC_by_Cou~99	127200.8	5208.528	24.42	0.000	116992.3	137409.3
EC_by_Nai~99	62446.09	15080.05	4.14	0.000	32889.74	92002.44
ur_rural00	1845.009	1761.832	1.05	0.295	-1608.119	5298.136
companies99	-.2906566	3.722467	-0.08	0.938	-7.586559	7.005245
_cons	-29510	2435.226	-12.12	0.000	-34282.96	-24737.05
qec02						
te02	-242.0809	5.52385	-43.82	0.000	-252.9075	-231.2544
va02	.5424735	.0081026	66.95	0.000	.5265927	.5583543
sw02	6.82224	.1093433	62.39	0.000	6.607931	7.036549
exp02	.5187617	.0238875	21.72	0.000	.4719432	.5655803
oe02	-256.7816	7.150038	-35.91	0.000	-270.7955	-242.7678
cw02	-.8137071	.0981184	-8.29	0.000	-1.006016	-.6213985
EC_by_Cou~02	130950.7	6169.929	21.22	0.000	118857.9	143043.6
EC_by_Nai~02	106030.4	11445.02	9.26	0.000	83598.52	128462.2
ur_rural00	-3493.303	2570.979	-1.36	0.174	-8532.33	1545.723
companies02	-.9179912	2.278451	-0.40	0.687	-5.383672	3.54769
_cons	-28542.75	2344.382	-12.17	0.000	-33137.66	-23947.85
qec03						
te03	-222.9438	5.688423	-39.19	0.000	-234.0929	-211.7947
va03	.6119687	.006689	91.49	0.000	.5988585	.625079
sw03	7.130464	.1002143	71.15	0.000	6.934047	7.32688
exp03	.2990463	.0222164	13.46	0.000	.2555029	.3425896
oe03	-333.0237	8.238673	-40.42	0.000	-349.1712	-316.8762
cw03	-.8485235	.0992403	-8.55	0.000	-1.043031	-.6540161
EC_by_Cou~03	118463.5	5179.987	22.87	0.000	108311	128616.1
EC_by_Nai~03	103667.1	11767.82	8.81	0.000	80602.57	126731.6
ur_rural00	-4821.397	2965.078	-1.63	0.104	-10632.84	990.0494
companies03	-1.846433	2.50192	-0.74	0.461	-6.750107	3.05724
_cons	-41674.57	2908.429	-14.33	0.000	-47374.99	-35974.16
qec04						
te04	-265.0428	5.927177	-44.72	0.000	-276.6598	-253.4257
va04	.5439177	.0062142	87.53	0.000	.5317382	.5560973
sw04	8.526642	.0972637	87.67	0.000	8.336009	8.717276
exp04	.3318412	.0202121	16.42	0.000	.2922262	.3714561
oe04	-357.2592	8.435387	-42.35	0.000	-373.7923	-340.7261
cw04	-.3713745	.0872332	-4.26	0.000	-.5423484	-.2004006
EC_by_Cou~04	114989.6	4809.326	23.91	0.000	105563.5	124415.8
EC_by_Nai~04	97324.09	12179.22	7.99	0.000	73453.25	121194.9
ur_rural00	-5283.781	3197.86	-1.65	0.098	-11551.47	983.91
companies04	-2.420911	2.455257	-0.99	0.324	-7.233127	2.391305
_cons	-47497.88	3320.391	-14.30	0.000	-54005.73	-40990.03
qec05						
te05	-308.7541	7.714351	-40.02	0.000	-323.874	-293.6343
va05	.4049793	.0055756	72.63	0.000	.3940514	.4159072

sw05	10.08781	.132728	76.00	0.000	9.827669	10.34795
exp05	.3863452	.0268076	14.41	0.000	.3338032	.4388871
oe05	-388.383	11.70926	-33.17	0.000	-411.3328	-365.4333
cw05	-.0161389	.1175701	-0.14	0.891	-.2465721	.2142942
EC_by_Cou~05	137233.1	6496.384	21.12	0.000	124500.4	149965.8
EC_by_Nai~05	109882.6	16851.98	6.52	0.000	76853.36	142911.9
ur_rural00	-7615.664	4095.858	-1.86	0.063	-15643.4	412.0705
companies05	-2.100787	2.99446	-0.70	0.483	-7.96982	3.768247
_cons	-62086.36	5148.47	-12.06	0.000	-72177.18	-51995.55
qte99						
ecom_sales99	-.0000475	7.79e-06	-6.10	0.000	-.0000628	-.0000323
va99	-.0001023	7.32e-06	-13.98	0.000	-.0001166	-.0000879
sw99	.0177759	.0000312	569.76	0.000	.0177147	.017837
cw99	.0000888	.0000387	2.29	0.022	.0000129	.0001648
as_edu00	.0000286	.0000371	0.77	0.441	-.0000441	.0001012
cou_uemp99	1.068347	2.209836	0.48	0.629	-3.262851	5.399546
cem1999	-.0001145	.0000274	-4.17	0.000	-.0001682	-.0000607
marr_hh00	-.0000275	.0000366	-0.75	0.453	-.0000993	.0000443
swva99	.3624441	.3567365	1.02	0.310	-.3367466	1.061635
_cons	97.24947	3.185473	30.53	0.000	91.00606	103.4929
qte02						
ecom_sales02	-.0001954	4.02e-06	-48.66	0.000	-.0002033	-.0001875
va02	.0000448	6.56e-06	6.83	0.000	.000032	.0000577
sw02	.0173463	.0000243	712.43	0.000	.0172985	.017394
cw02	-.0000889	.0000305	-2.92	0.004	-.0001487	-.0000292
as_edu00	.0000298	.0000321	0.93	0.353	-.0000332	.0000928
cou_uemp02	.5114531	1.895013	0.27	0.787	-3.202703	4.225609
cme2002	-.0000398	.0000261	-1.52	0.128	-.000091	.0000114
marr_hh00	-.0000555	.0000314	-1.77	0.077	-.0001171	6.04e-06
swva02	-.1061017	.0557635	-1.90	0.057	-.2153961	.0031928
_cons	82.63942	2.741218	30.15	0.000	77.26673	88.01211
qte03						
ecom_sales03	-.0002326	3.32e-06	-70.15	0.000	-.0002391	-.0002261
va03	.0000946	5.47e-06	17.30	0.000	.0000839	.0001054
sw03	.0166385	.0000224	741.27	0.000	.0165945	.0166825
cw03	-.0000917	.0000291	-3.15	0.002	-.0001488	-.0000346
as_edu00	.0000217	.0000346	0.63	0.531	-.0000462	.0000896
cou_uemp03	.2063904	2.089167	0.10	0.921	-3.888301	4.301082
cme2003	-.0000424	.0000294	-1.44	0.149	-.0001	.0000152
marr_hh00	-.0000508	.0000341	-1.49	0.137	-.0001177	.0000161
swva03	-.0046762	.131277	-0.04	0.972	-.2619743	.2526219
_cons	79.82208	2.987292	26.72	0.000	73.96709	85.67706
qte04						
ecom_sales04	-.0002189	2.83e-06	-77.48	0.000	-.0002245	-.0002134
va04	.0000872	4.67e-06	18.68	0.000	.0000781	.0000964
sw04	.0164032	.0000219	750.13	0.000	.0163603	.016446
cw04	-.0000707	.0000238	-2.98	0.003	-.0001173	-.0000242
as_edu00	.000015	.0000339	0.44	0.659	-.0000515	.0000815
cou_uemp04	.1193237	2.047065	0.06	0.954	-3.89285	4.131497
cme2004	-.0000549	.0000292	-1.88	0.060	-.0001122	2.33e-06
marr_hh00	-.0000458	.0000332	-1.38	0.168	-.000111	.0000193
swva04	-.016004	.089806	-0.18	0.859	-.1920204	.1600125
_cons	75.28197	2.949873	25.52	0.000	69.50033	81.06362
qte05						
ecom_sales05	-.0001546	2.77e-06	-55.81	0.000	-.0001601	-.0001492
va05	.0000288	3.53e-06	8.16	0.000	.0000219	.0000357
sw05	.0161585	.0000228	709.67	0.000	.0161138	.0162031
cw05	-.0000559	.0000259	-2.16	0.031	-.0001066	-5.19e-06
as_edu00	.0000105	.0000333	0.32	0.751	-.0000547	.0000758
cou_uemp05	.3010822	2.046775	0.15	0.883	-3.710522	4.312687
cme2005	-.0000457	.0000296	-1.54	0.122	-.0001038	.0000123
marr_hh00	-.0000451	.0000325	-1.39	0.165	-.0001088	.0000186
swva05	-.0539598	.0726033	-0.74	0.457	-.1962596	.0883399
_cons	72.77259	2.955738	24.62	0.000	66.97945	78.56573
qsw99						
te99	54.9	.095529	574.69	0.000	54.71276	55.08723
va99	.0063084	.0004116	15.33	0.000	.0055017	.007115
ecom_sales99	.007389	.0004484	16.48	0.000	.0065102	.0082678
as_edu00	.0010856	.0006043	1.80	0.072	-.0000988	.00227
mw1998	127.7714	202.1577	0.63	0.527	-268.4505	523.9933
popden99	.012668	.0111836	1.13	0.257	-.0092514	.0345874
ctw1999	-6.41e-06	5.54e-06	-1.16	0.247	-.0000173	4.44e-06
cwm1999	.0000993	.0000196	5.06	0.000	.0000609	.0001378
spe99	-798.1144	781.3222	-1.02	0.307	-2329.478	733.2489
_cons	-5913.602	1049.091	-5.64	0.000	-7969.783	-3857.422

qsw02						
te02	56.75384	.078567	722.36	0.000	56.59985	56.90783
va02	.0008312	.0003717	2.24	0.025	.0001026	.0015598
ecom_sales02	.0083738	.0002326	35.99	0.000	.0079178	.0088298
as_edu00	.001332	.0005419	2.46	0.014	.0002699	.0023941
mw2002	-22.75572	34.62202	-0.66	0.511	-90.61364	45.1022
popden02	.0200919	.0099664	2.02	0.044	.0005581	.0396257
ctw2002	-6.39e-06	3.90e-06	-1.64	0.101	-.000014	1.26e-06
cwm2002	.000078	.000021	3.71	0.000	.0000368	.0001193
spe02	156.3961	99.4842	1.57	0.116	-38.58936	351.3815
_cons	-4501.892	200.5803	-22.44	0.000	-4895.022	-4108.762
qsw03						
te03	58.97335	.0796346	740.55	0.000	58.81727	59.12943
va03	-.0024707	.0003303	-7.48	0.000	-.0031181	-.0018233
ecom_sales03	.0117031	.0002039	57.40	0.000	.0113035	.0121027
as_edu00	.0015747	.0006045	2.60	0.009	.0003899	.0027596
mw2003	-.5830051	34.52699	-0.02	0.987	-68.25465	67.08864
popden03	.0251105	.0111042	2.26	0.024	.0033467	.0468744
ctw2003	-6.88e-06	4.28e-06	-1.61	0.108	-.0000153	1.51e-06
cwm2003	.0000831	.0000223	3.72	0.000	.0000393	.0001269
spe03	-18.18844	352.7069	-0.05	0.959	-709.4812	673.1043
_cons	-4590.17	204.298	-22.47	0.000	-4990.587	-4189.754
qsw04						
te04	59.7773	.0802009	745.34	0.000	59.6201	59.93449
va04	-.002525	.0002881	-8.76	0.000	-.0030897	-.0019603
ecom_sales04	.011839	.000177	66.90	0.000	.0114922	.0121859
as_edu00	.0018668	.0005873	3.18	0.001	.0007158	.0030178
mw2004	3.952668	30.30344	0.13	0.896	-55.44099	63.34632
popden04	.025522	.0111581	2.29	0.022	.0036525	.0473914
ctw2004	-6.86e-06	4.06e-06	-1.69	0.091	-.0000148	1.09e-06
cwm2004	.0000867	.0000224	3.87	0.000	.0000428	.0001306
spe04	21.04056	205.1978	0.10	0.918	-381.1398	423.2209
_cons	-4395.748	185.0073	-23.76	0.000	-4758.355	-4033.14
qsw05						
te05	60.68049	.084886	714.85	0.000	60.51412	60.84687
va05	-.0007292	.0002188	-3.33	0.001	-.0011581	-.0003003
ecom_sales05	.0095163	.0001723	55.22	0.000	.0091785	.009854
as_edu00	.0020615	.0005798	3.56	0.000	.000925	.0031979
mw2005	24.08447	27.83576	0.87	0.387	-30.47261	78.64155
popden05	.0211413	.0111808	1.89	0.059	-.0007727	.0430553
ctw2005	-5.22e-06	3.85e-06	-1.35	0.176	-.0000128	2.34e-06
cwm2005	.0000702	.000021	3.34	0.001	.0000291	.0001113
spe05	93.10934	120.3431	0.77	0.439	-142.7588	328.9775
_cons	-4395.596	177.7293	-24.73	0.000	-4743.939	-4047.253

Model 4: Three-stage least-squares regression with SURE option and economic area measures.

Equation	Obs	Parms	RMSE	"R-sq"	chi2	P
qec99ea	17769	9	107917.1	0.2149	4910.31	0.0000
qec02ea	17769	9	164661.4	0.4867	20432.56	0.0000
qec03ea	17769	9	191239.3	0.5374	27135.58	0.0000
qec04ea	17769	9	213090.7	0.4977	27432.12	0.0000
qec05ea	17769	9	256708	0.4221	20113.05	0.0000
qte99ea	17769	9	192.2496	0.8781	392939.93	0.0000
qte02ea	17769	8	173.3794	0.8885	570794.23	0.0000
qte03ea	17769	9	184.3939	0.8626	577704.21	0.0000
qte04ea	17769	9	181.7005	0.8608	585528.88	0.0000
qte05ea	17769	9	182.6249	0.8551	518448.03	0.0000
qsw99ea	17769	9	10627.29	0.8820	412507.65	0.0000
qsw02ea	17769	8	9868.017	0.8938	590942.96	0.0000
qsw03ea	17769	9	10893.06	0.8708	593414.29	0.0000
qsw04ea	17769	9	10895.81	0.8704	599160.10	0.0000
qsw05ea	17769	9	11144.09	0.8632	542401.97	0.0000

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
qec99ea						
te99	13.40123	4.314216	3.11	0.002	4.945525	21.85694
va99	.099328	.00705	14.09	0.000	.0855102	.1131458
sw99	1.004014	.0848928	11.83	0.000	.837627	1.170401
exp99	.5443527	.0204212	26.66	0.000	.5043278	.5843776
oe99	-91.68501	5.619102	-16.32	0.000	-102.6982	-80.67177
cw99	-.3364966	.07299	-4.61	0.000	-.4795544	-.1934388
EC_by_EA99	103190.3	9599.299	10.75	0.000	84376.03	122004.6
EC_by_Nai~99	81276.85	15275.94	5.32	0.000	51336.56	111217.2
companies9~A	.0001011	.0019805	0.05	0.959	-.0037806	.0039827
_cons	-28409.56	2663.556	-10.67	0.000	-33630.03	-23189.08
qec02ea						
te02	-244.3732	5.526211	-44.22	0.000	-255.2044	-233.5421
va02	.5457655	.0081552	66.92	0.000	.5297816	.5617493
sw02	6.911355	.109855	62.91	0.000	6.696044	7.126667
exp02	.5264439	.0240764	21.87	0.000	.4792549	.5736328
oe02	-261.0817	7.196851	-36.28	0.000	-275.1873	-246.9761
cw02	-.8298933	.0987208	-8.41	0.000	-1.023383	-.6364041
EC_by_EA02	94877.14	9267.069	10.24	0.000	76714.02	113040.3
EC_by_Nai~02	112850.7	11520.05	9.80	0.000	90271.8	135429.6
companie~2EA	.0000274	.0000948	0.29	0.773	-.0001584	.0002131
_cons	-28239.27	2598.21	-10.87	0.000	-33331.67	-23146.88
qec03ea						
te03	-225.7196	5.680821	-39.73	0.000	-236.8538	-214.5854
va03	.6140165	.0067269	91.28	0.000	.6008321	.6272009
sw03	7.220555	.1005182	71.83	0.000	7.023543	7.417567
exp03	.3030367	.0223283	13.57	0.000	.2592741	.3467993
oe03	-336.1756	8.266979	-40.66	0.000	-352.3786	-319.9726
cw03	-.8643557	.0997494	-8.67	0.000	-1.059861	-.6688504
EC_by_EA03	87199.11	7864.136	11.09	0.000	71785.68	102612.5
EC_by_Nai~03	111621.1	11809.46	9.45	0.000	88474.95	134767.2
companie~3EA	.0000955	.0007619	0.13	0.900	-.0013977	.0015887
_cons	-42572.42	3149.154	-13.52	0.000	-48744.64	-36400.19
qec04ea						
te04	-266.9564	5.926171	-45.05	0.000	-278.5715	-255.3413
va04	.5464947	.0062575	87.33	0.000	.5342302	.5587592
sw04	8.598141	.0976765	88.03	0.000	8.406698	8.789583
exp04	.3363424	.0203356	16.54	0.000	.2964854	.3761995
oe04	-360.8551	8.468007	-42.61	0.000	-377.4521	-344.2581
cw04	-.381461	.0876995	-4.35	0.000	-.5533489	-.2095731
EC_by_EA04	86329.51	7875.783	10.96	0.000	70893.26	101765.8
EC_by_Nai~04	103621.3	12229.44	8.47	0.000	79652.04	127590.6
companie~4EA	-.0005659	.0008456	-0.67	0.503	-.0022232	.0010915
_cons	-47760.26	3581.631	-13.33	0.000	-54780.13	-40740.39
qec05ea						
te05	-309.9102	7.713611	-40.18	0.000	-325.0286	-294.7918
va05	.4072946	.0056164	72.52	0.000	.3962868	.4183025
sw05	10.15354	.1333487	76.14	0.000	9.892178	10.4149
exp05	.3909031	.0269873	14.48	0.000	.3380091	.4437972
oe05	-393.2304	11.76086	-33.44	0.000	-416.2813	-370.1796

cw05	-.0204228	.1182159	-0.17	0.863	-.2521217	.2112762
EC_by_EA05	109475.3	10481.33	10.44	0.000	88932.3	130018.4
EC_by_Nai~05	118217.9	16918.36	6.99	0.000	85058.55	151377.3
companie~5EA	-.0009606	.0010074	-0.95	0.340	-.0029351	.0010139
_cons	-63251.53	5668.426	-11.16	0.000	-74361.44	-52141.62
qte99ea						
ecom_sales99	-.0000457	7.82e-06	-5.84	0.000	-.0000611	-.0000304
va99	-.0001027	7.36e-06	-13.94	0.000	-.0001171	-.0000882
sw99	.0177766	.0000317	560.27	0.000	.0177144	.0178388
cw99	.0000892	.0000396	2.26	0.024	.0000117	.0001667
as_edu00EA	2.40e-09	1.61e-08	0.15	0.881	-2.91e-08	3.39e-08
EA_unemp99	7.18839	4.290974	1.68	0.094	-1.221765	15.59854
cem1999EA	-1.64e-07	5.45e-08	-3.00	0.003	-2.71e-07	-5.70e-08
marr_hh99EA	5.07e-08	3.35e-08	1.52	0.130	-1.49e-08	1.16e-07
swva99	.3710129	.3619376	1.03	0.305	-.3383718	1.080398
_cons	85.91791	6.012699	14.29	0.000	74.13324	97.70259
qte02ea						
ecom_sales02	-.0001983	4.02e-06	-49.32	0.000	-.0002061	-.0001904
va02	.0000459	6.57e-06	6.98	0.000	.000033	.0000588
sw02	.0173565	.0000246	706.24	0.000	.0173083	.0174047
cw02	-.0000917	.0000308	-2.98	0.003	-.000152	-.0000313
as_edu00EA	-8.74e-09	5.96e-09	-1.47	0.143	-2.04e-08	2.94e-09
EA_unemp02	1.402894	3.338013	0.42	0.674	-5.139491	7.945279
cme2002EA	6.09e-09	4.24e-09	1.43	0.152	-2.23e-09	1.44e-08
marr_hh02EA	-2.49e-09	1.66e-09	-1.51	0.132	-5.74e-09	7.51e-10
swva02	-.0978865	.0558958	-1.75	0.080	-.2074404	.0116673
_cons	78.76209	4.723204	16.68	0.000	69.50478	88.0194
qte03ea						
ecom_sales03	-.0002358	3.32e-06	-71.13	0.000	-.0002423	-.0002293
va03	.000096	5.47e-06	17.54	0.000	.0000853	.0001067
sw03	.0166515	.0000226	736.66	0.000	.0166072	.0166958
cw03	-.0000917	.0000294	-3.12	0.002	-.0001492	-.0000341
as_edu00EA	-8.91e-09	8.11e-09	-1.10	0.272	-2.48e-08	6.98e-09
EA_unemp03	1.855982	3.094972	0.60	0.549	-4.210052	7.922016
cme2003EA	3.39e-08	3.77e-08	0.90	0.369	-4.00e-08	1.08e-07
marr_hh03EA	-1.29e-08	1.45e-08	-0.89	0.375	-4.13e-08	1.55e-08
swva03	-.0039019	.1312996	-0.03	0.976	-.2612443	.2534405
_cons	74.19881	4.452358	16.67	0.000	65.47235	82.92527
qte04ea						
ecom_sales04	-.0002213	2.83e-06	-78.29	0.000	-.0002268	-.0002157
va04	.0000886	4.68e-06	18.95	0.000	.0000794	.0000977
sw04	.0164081	.000022	746.12	0.000	.016365	.0164512
cw04	-.000071	.0000239	-2.97	0.003	-.0001179	-.0000242
as_edu00EA	-6.04e-09	8.29e-09	-0.73	0.467	-2.23e-08	1.02e-08
EA_unemp04	.6528935	2.0933	0.31	0.755	-3.4499	4.755687
cme2004EA	2.80e-08	4.47e-08	0.63	0.531	-5.96e-08	1.16e-07
marr_hh04EA	-1.53e-08	1.68e-08	-0.91	0.361	-4.82e-08	1.76e-08
swva04	-.0194055	.0899717	-0.22	0.829	-.1957469	.1569358
_cons	71.02043	3.224798	22.02	0.000	64.69994	77.34092
qte05ea						
ecom_sales05	-.0001563	2.78e-06	-56.31	0.000	-.0001617	-.0001508
va05	.00003	3.54e-06	8.47	0.000	.0000231	.0000369
sw05	.0161561	.0000229	705.65	0.000	.0161113	.016201
cw05	-.0000555	.000026	-2.13	0.033	-.0001065	-4.44e-06
as_edu00EA	-3.13e-09	8.68e-09	-0.36	0.718	-2.01e-08	1.39e-08
EA_unemp05	-.0650729	.2597538	-0.25	0.802	-.574181	.4440353
cme2005EA	5.77e-08	4.80e-08	1.20	0.229	-3.63e-08	1.52e-07
marr_hh05EA	-2.84e-08	1.78e-08	-1.59	0.111	-6.34e-08	6.53e-09
swva05	-.0453753	.0730163	-0.62	0.534	-.1884846	.097734
_cons	70.12956	1.540859	45.51	0.000	67.10953	73.14959
qsw99ea						
te99	54.87523	.0968661	566.51	0.000	54.68538	55.06508
va99	.0063446	.0004132	15.36	0.000	.0055349	.0071544
ecom_sales99	.0074636	.0004498	16.59	0.000	.006582	.0083452
as_edu00EA	2.97e-07	6.04e-07	0.49	0.622	-8.86e-07	1.48e-06
mw1998	216.3123	212.0827	1.02	0.308	-199.3622	631.9868
popdenEA99	.2102511	.0743059	2.83	0.005	.0646142	.3558879
ctw1999EA	-2.27e-08	9.69e-09	-2.35	0.019	-4.17e-08	-3.76e-09
cwm1999EA	1.34e-07	3.30e-08	4.05	0.000	6.89e-08	1.98e-07
spe99	-819.5979	791.9882	-1.03	0.301	-2371.866	732.6704
_cons	-6342.874	1102.498	-5.75	0.000	-8503.731	-4182.018
qsw02ea						
te02	56.71187	.0792058	716.01	0.000	56.55663	56.86711
va02	.0007819	.0003727	2.10	0.036	.0000515	.0015123

ecom_sales02	.0085453	.000233	36.67	0.000	.0080885	.0090021
as_edu00EA	1.63e-07	3.56e-07	0.46	0.647	-5.35e-07	8.61e-07
mw2002	12.34791	41.34068	0.30	0.765	-68.67832	93.37415
popdenEA02	.2256904	.0465856	4.84	0.000	.1343842	.3169966
ctw2002EA	-2.61e-10	4.04e-10	-0.65	0.518	-1.05e-09	5.30e-10
cwm2002EA	3.20e-09	2.61e-09	1.22	0.221	-1.92e-09	8.32e-09
spe02	142.4249	99.81681	1.43	0.154	-53.21244	338.0623
_cons	-4671.867	238.4096	-19.60	0.000	-5139.141	-4204.592
qsw03ea						
te03	58.91894	.0800635	735.90	0.000	58.76202	59.07587
va03	-.0025237	.0003303	-7.64	0.000	-.0031712	-.0018763
ecom_sales03	.0118585	.0002038	58.18	0.000	.011459	.0122581
as_edu00EA	2.23e-07	4.60e-07	0.48	0.628	-6.78e-07	1.12e-06
mw2003	22.42819	40.41217	0.55	0.579	-56.77821	101.6346
popdenEA03	.2545909	.0546971	4.65	0.000	.1473866	.3617952
ctw2003EA	-3.17e-09	3.53e-09	-0.90	0.369	-1.01e-08	3.75e-09
cwm2003EA	2.87e-08	1.80e-08	1.59	0.111	-6.60e-09	6.41e-08
spe03	-15.78926	352.9453	-0.04	0.964	-707.5494	675.9708
_cons	-4663.008	238.4148	-19.56	0.000	-5130.293	-4195.724
qsw04ea						
te04	59.75515	.0805813	741.55	0.000	59.59721	59.91308
va04	-.0025942	.0002883	-9.00	0.000	-.0031592	-.0020291
ecom_sales04	.0119512	.000177	67.53	0.000	.0116044	.0122981
as_edu00EA	5.05e-08	4.78e-07	0.11	0.916	-8.87e-07	9.88e-07
mw2004	20.98114	35.03542	0.60	0.549	-47.68702	89.64931
popdenEA04	.2406796	.0542502	4.44	0.000	.1343511	.347008
ctw2004EA	-2.46e-09	3.62e-09	-0.68	0.496	-9.55e-09	4.63e-09
cwm2004EA	4.00e-08	2.16e-08	1.85	0.064	-2.34e-09	8.23e-08
spe04	23.14859	205.511	0.11	0.910	-379.6456	425.9428
_cons	-4422.646	211.9554	-20.87	0.000	-4838.071	-4007.221
qsw05ea						
te05	60.69018	.0853193	711.33	0.000	60.52296	60.8574
va05	-.0008034	.000219	-3.67	0.000	-.0012327	-.0003741
ecom_sales05	.0096098	.0001724	55.74	0.000	.0092719	.0099478
as_edu00EA	-8.45e-08	4.98e-07	-0.17	0.865	-1.06e-06	8.92e-07
mw2005	32.4529	32.03862	1.01	0.311	-30.34165	95.24744
popdenEA05	.2114021	.0539811	3.92	0.000	.1056011	.3172031
ctw2005EA	9.22e-10	3.68e-09	0.25	0.802	-6.29e-09	8.13e-09
cwm2005EA	2.76e-08	2.14e-08	1.29	0.197	-1.44e-08	6.96e-08
spe05	84.36702	120.8855	0.70	0.485	-152.5642	321.2982
_cons	-4390.044	198.7041	-22.09	0.000	-4779.497	-4000.591

Variable Key:
E-Commerce Sales (ecom_salesXX)
Establishment Outputs (vaXX)
Total Employment (teXX)
Non-Production Employees (oeXX)
Total Salaries and Wages (swXX)
Establishment Exports (expXX)
Outsourcing Costs (cwXX)
E-Commerce Intensity by County (EC_by_CountyXX)
E-Commerce Intensity by Economic Area (EC_by_EAXX)
E-Commerce Intensity by NAICS Code (EC_by_NaicsXX)
Urban/Rural Dummy Variable (ur_ruralXX)
Broadband Competition (companiesXX)
Education (as_edu00)
County Unemployment Ratio (cou_uempXX)
County Employment in Manufacturing (cmeXXXX)
Married Households (marr_hhXX)
Establishment Labor Costs (swvaXX)
Minimum Wage (mwXXXX)
Population Density
County Total Wage (ctwXXXX)
County Wage in Manufacturing (cwmXXXX)
Establishment Employee Value (speXX)

APPENDIX C

Census Memo for Clearance Request

<u>Memo</u>

I am requesting part of the text used for my Clearance Request form be released for project documentation purposes and records.

Models Requested:
I am requesting clearance of four regression based models (Three Stage Least Squares Regression-3SLS) that determine the characteristics of establishments that adopted electronic commerce. Four Models are necessary due to the complexity of the various methodological constraints in estimating the models and the two levels of geographical measurement. Model 1 provides the results from the 3SLS taking into account the endogenous nature of several variables with several county level measures. Model 2 performs the same estimation procedure as conducted on Model 1, however, instead of using several county level measures it is aggregated to the economic area. Model 3 and Model 4 provides the results from the 3SLS model, using the SURE option. The SURE (Seemingly Unrelated Regression) option allows for all variables on the right side of the equation to be considered exogenous. Thus, the only difference between Models 1-4 is:

Model 1: 3SLS with Endogenous variables with County level variables
Model 2: 3SLS with Endogenous variables with Economic Area variables
Model 3: 3SLS with SURE option with County level variables
Model 4: 3SLS with SURE option with Economic Area variables

Please state how the outputs are part of the research project as approved (Note: If these outputs are described in your proposal, merely refer us there.)

These outputs are directly related and described in our proposal under Criterion 11.

Please indicate how you expect the output to be presented (Check all that apply):

_X__ Journal paper
___ Working paper (Don't forget about the CES Discussion Paper Series)
_X_ Dissertation
___ Book chapter
___ Presentation at a conference
___ Report (e.g., put out by policy organization)
___ Memo for internal use
___ Supporting or intermediate output not to be published in any of the above
___ Other (please specify):

2A. DESCRIPTIONS OF RESEARCH SAMPLES:
Describe your Research sample(s) or "cuts" of data used in research output. For each sample, please describe your selection criteria and how the research sample differs from the samples underlying survey publications or other samples you have used. Take as much space as you need for each; add samples as needed.

SAMPLE 1: Our sample utilizes longitudinal data from the 1999 ASM, the 1999 CNUS, the 2002CM, the 2003 ASM, the 2004 ASM, and the 2005 ASM. The sample is limited to those establishments that contain observations for each of the above stated years. This sample was also restricted to those establishments that contained data on our variable of interest--e-commerce sales and those establishments located in U.S. counties. This sample does not include establishments located in Washington, D.C. This sample also contains "outside data" that provides additional county and economic area information.

2B. RELATIONSHIP BETWEEN SAMPLES

Describe how your samples relate to each other (e.g., if you have two samples, is one a subsample of another?) In the cases of samples and subsamples, there is an implicit third sample, the difference between the two. Please describe this sample above. We probably will need to examine any implicit samples as well.

Sample 1 contains data from the years 1999, 2002, 2003, 2004, and 2005. We did attempt to create one continuous longitudinal sample from 1999-2005. However, there are several issues with the 2000 CNUS data (the data set that contained our variable of interested). For example, significantly fewer establishments filled out the 2000 CNUS as compared to the 1999 CNUS and it unclear if the appropriate person filled the survey out. The 2001 ASM survey was not included in the sample because the e-commerce data for 2001 was not available.

2C. RELATIONSHIP TO OTHER PUBLICATIONS
Describe how your samples may relate to similar samples from other projects or from survey publications. (e.g., how your sample of an industry in the LRD differs from the Census of Manufactures or Annual Survey of Manufactures files in the LRD).

Our sample is different from other research projects and survey publications in that it (to the extent of the researchers knowledge) is one of the first longitudinal data sets to link e-commerce from 1999-2005 Our analysis does not conflict with the survey results that have been published through the e-stats reports.

VARIABLE DEFINITIONS

VARIABLE NAME: E-Commerce Sales (ecom_salesXX)

DEFINITION: E-Commerce Sales is a continuous variable that reports the total sales by e-commerce for an establishment. SOURCE: ASM Survey 1999,2003,2004,2005, CM 2002, and the 1999 CNUS
COMMENTS: Since e-commerce is reported in percentages I used the total value of sales for the establishment and the percentage of electronic sales by establishment to construct a continuous variable for the establishments e-commerce sales.

VARIABLE NAME:Establishment Outputs (vaXX)
DEFINITION: Establishment Outputs is derived variable constructed by the Census Bureau the uses the following formula (TVS +(WIE-WIB)+(FIE-FIB)). Utilizing this variable avoids the duplication in value of shipments that results from the use of products of some establishments as materials by others. As such, it is considered to be the best measure available for comparing the relative importance of manufacturing among industries and geographical area.
SOURCE: ASM Survey 1999, 2003, 2004, 2005 and CM 2002
COMMENTS:

VARIABLE NAME: Total Employment (teXX)
DEFINITION: Total Employment is the sum of the average number of production workers and non-production workers in an establishment.
SOURCE: ASM Survey 1999, 2003, 2004, 2005 and CM 2002
COMMENTS:

VARIABLE NAME: Non-Production Employees (oeXX)
DEFINITION: Non-production employees are those that are involved in factory supervision, sales, sales delivery, clerical and routine office functions, shipping, and record keeping among other non-production activities. This does not include proprietors or partners of the establishment.
SOURCE: ASM Survey 1999, 2003, 2004, 2005 and CM 2002
COMMENTS:

VARIABLE NAME: Total Salaries and Wages (swXX)
DEFINITION: The gross earnings paid in a calender year to employees.
SOURCE:ASM Survey 1999, 2003, 2004, 2005 and CM 2002
COMMENTS:

VARIABLE NAME: Establishment Exports (expXX)
DEFINITION: Includes all exports going directly for export. It includes shipments of products to export firms and other customers that will export items It excludes the value of products which will be further manufactured, fabricated, or assembled in this country before being shipped to foreign customers.
SOURCE: ASM Survey 1999, 2003, 2004, 2005 and CM 2002
COMMENTS:

VARIABLE NAME: Outsourcing Costs (cwXX)

DEFINITION: Outsourcing Costs are the total payments made during the year for contract work done by others on materials furnished by the establishment.
SOURCE: ASM Survey 1999, 2003, 2004, 2005 and CM 2002
COMMENTS:

VARIABLE NAME: E-Commerce Intensity by County (EC_by_CountyXX)
DEFINITION: E-Commerce by Intensity by County was constructed by collapsing TVS for every establishment in a county. E-Commerce Sales by establishment were also collapsed by county. E-Commerce sales were then divided by TVS (by county) to determine the e-commerce intensity in that county.
SOURCE: ASM Survey 1999, 2003, 2004, 2005 and CM 2002
COMMENTS:

VARIABLE NAME: E-Commerce Intensity by Economic Area (EC_by_EAXX)
DEFINITION: E-Commerce by Intensity by Economic Area was constructed by collapsing TVS for every establishment in an economic erea (as defined by the Bureau of Economic Analysis). E-Commerce Sales by establishment were also collapsed by economic area. E-Commerce sales were then divided by TVS (by economic area) to determine the e-commerce intensity in that economic area.
SOURCE: ASM Survey 1999, 2003, 2004, 2005 and CM 2002 and Bureau of Economic Analysis for the Economic Area codes
COMMENTS:

VARIABLE NAME: E-Commerce Intensity by NAICS Code (EC_by_NaicsXX)
DEFINITION: E-Commerce Intensity by NAICS was constructed by collapsing TVS by the three digit NAICS code. E-Commerce Sales were then collapsed by NAICS code as well. The E-Commerce intensity by NAICS variable was constructed by dividing E-Commerce Sales by TVS for the particular NAICS code.
SOURCE: ASM Survey 1999, 2003, 2004, 2005
COMMENTS:

VARIABLE NAME: Urban/Rural Dummy Variable (ur_ruralXX)
DEFINITION: The Urban/Rural dummy variable provides a simplistic measure of the urbanity of a county. It is codes where urban = 1 and rural = 0. Using the Rural-Urban continuum does as produced by the USDA, counties that received their coding of 1-3 was coded as urban and counties that received a coding of 4-9 received a coding of rural.
SOURCE: United States Department of Agriculture
COMMENTS:

VARIABLE NAME: Broadband Competition (companiesXX)
DEFINITION: Broadband competition is a variable that measures the total number of broadband providers in a county or in an economic area.
SOURCE: FCC
COMMENTS: Part of my outside data

VARIABLE NAME: Education (as_eduXX)

DEFINITION: Education is defined as the number of individuals that have and associates or technical degree in a county.
SOURCE: Census Bureau
COMMENTS: Part of my outside data

VARIABLE NAME: County Unemployment Ratio (cou_uempXX)
DEFINITION: The county unemployment ratio is derived using the following formula: ((County Employment - Establishment Employment)/County Workforce/Establishment)
SOURCE: Bureau of Economic Analysis and the ASM 1999, 2003, 2004, 2005 and the CM 2002
COMMENTS: Part of my outside data combined with the establishment data.

VARIABLE NAME: County Employment in manufacturing (cmeXXXX)
DEFINITION: The number of people in a county that work in Manufacturing.
SOURCE: Bureau of Economic Analysis
COMMENTS: Part of my outside data

VARIABLE NAME: Married Households (marr_hhXX)
DEFINITION: The number of married households in a county
SOURCE: Census Bureau
COMMENTS: Part of my outside data

VARIABLE NAME: Establishment Labor Costs (swvaXX)
DEFINITION: Unit labor cost is a constructed variable of the ratio of (sw/va) for each establishment. It is used to determine labor costs in the establishment.
SOURCE: ASM 1999, 2003, 2004, 2005, and CM 2002
COMMENTS: Part of my outside data

VARIABLE NAME: Minimum Wage (mwXXXX)
DEFINITION: The minimum wage rate per state
SOURCE: Bureau of Labor Statistics
COMMENTS: Part of my outside data

VARIABLE NAME: Population Density
DEFINITION: The population density of a county.
SOURCE: Census Bureau
COMMENTS: Part of my outside data

VARIABLE NAME: County Total Wage (ctwXXXX)
DEFINITION: the total wages in a county.
SOURCE: Bureau of Economic Analysis
COMMENTS: Part of my outside data

VARIABLE NAME: County Wage in manufacturing (cwmXXXX)
DEFINITION: the total wages in a county for those employed in manufacturing.
SOURCE: Bureau of Economic Analysis

COMMENTS: Part of my outside data

VARIABLE NAME: Establishment Employee Value (speXX)
DEFINITION: Establishment Employee Value is a constructed variable using the ratio of (te/va) for each establishment.
SOURCE: ASM 1999, 2003, 2004, 2005, and CM 2002
COMMENTS:

APPENDIX D

User Provided Data Memo

Date: 12/08/2009
Project ID: Ch00545
Researcher Name: Candice Wallace

Each data set that you would like uploaded requires a separate User Provided Data Memo.

File information:

For SAS data set, paste "PROC CONTENTS" here AND fill in #2 below[14]:

For Stata data set, paste "DESCRIBE" here:

```
                storage  display     value
variable name    type    format      label      variable label
----------------------------------------------------------------------
--------
state           str20  %20s                     State
zipcode         long   %12.0g                   ZipCode
companies       byte   %10.0g                   Number of Holding
Companies
```

For any other data set, fill in all of the following (for SAS data fill in #2):

1. File name: 99BB.dta
2. File size (KB): 438 KB
3. File type: dta
4. Number of records: 17889
5. List of variables (record layout is sufficient): state, zip code, and companies

Destination Location for Files:
RDC server path (e.g. rdc04:/rdcprojects/br00554/data):

rdcprojects/ch1/ch00545/data/Dissertation_Data/Outside_data

Permissions for the Files:
The default settings will set the owner of the file as the researcher submitting the request, the group will be your project group, and the files will have read-only access for the owner and the group. Fill in the following *ONLY IF* you want these changed.

[14] Earlier versions of SAS data sets **must** be in Unix SAS format. PC SAS data before version 8 are not compatible.

1. Owner:
2. Group:
3. Permissions:

Permissions (mark all that apply):

__X__ The data are public use and…

___ downloaded from the internet. The **exact** URL(s) is(are): www.fcc.gov/wcb/iatd/comp.html

___ procured other than from the internet. Attached is evidence of public use.

___ The data are purchased. Attached is a receipt of purchase or documentation from my institution that it subscribes to this data.

___ The data are proprietary. Attached is written permission from the data custodian or vendor expressing consent to use the data on the RDC computer system and specifying any restrictions on the data's use.

Description (1-2 sentence description of the data):
This data set contains information about the number of broadband companies, by zip code, for the year 1999.

REFERENCES

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<u>Selected Conference Presentations and Workshops</u>

Gibson, J. and C. Wallace. 2013. “Outsourcing and Its Impact on Knowledge Management: A Case Study of the Kentucky Transportation Cabinet.” Presented at the Transportation Research Board Annual Meeting. Washington, D.C. January 2013.

Gibson, J., D. Denison, D. Kreis and C. Wallace. 2013. “Transportation Revenues and Expenditures in Kentucky: Measuring Historical Sufficiency and Defining Future Scenarios.” Presented at the Association for Budgeting and Financial Management Annual Conference 2013: Washington, D.C.

Wallace, C. 2011. “A Tribute to Tom Leinbach.” Panel participant at the Annual Meeting of the Association of American Geographers. Seattle, WA. April 2011.

Wallace, C. 2009. “Manufacturing Solutions: Explaining E-commerce Adoption in the U.S. Manufacturing Industry.” Presented at the Association of American Geographers. Las Vegas, NV. March 2009.

Wallace, C. 2008. Summer Institute in Economic Geography. Manchester, England.

Wallace, C. and J. Yusuf. 2007. “Southern and Eastern Kentucky 511 Tourism Information Service: An Economic Impact Evaluation." Presented at the Association of American Geographers. San Francisco, CA. April 2007.

O’Connell, L., J. Yusuf, C. Wallace, and M. Hackbart. 2006. “Enhancing State DOT Performance: The Role of Independent Transportation Commissions." Presented at the Transportation Research Board Annual Meeting. Washington, DC. January 2006.

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TRANSPORTATION RESEARCH BOARD COMMITTEE MEMBER FOR FREIGHT AND MARINE TRANSPORTATION YOUNG MEMBERS COUNCIL (2013-2016)

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CRUM AWARD (UNIVERSITY OF KENTUCKY)